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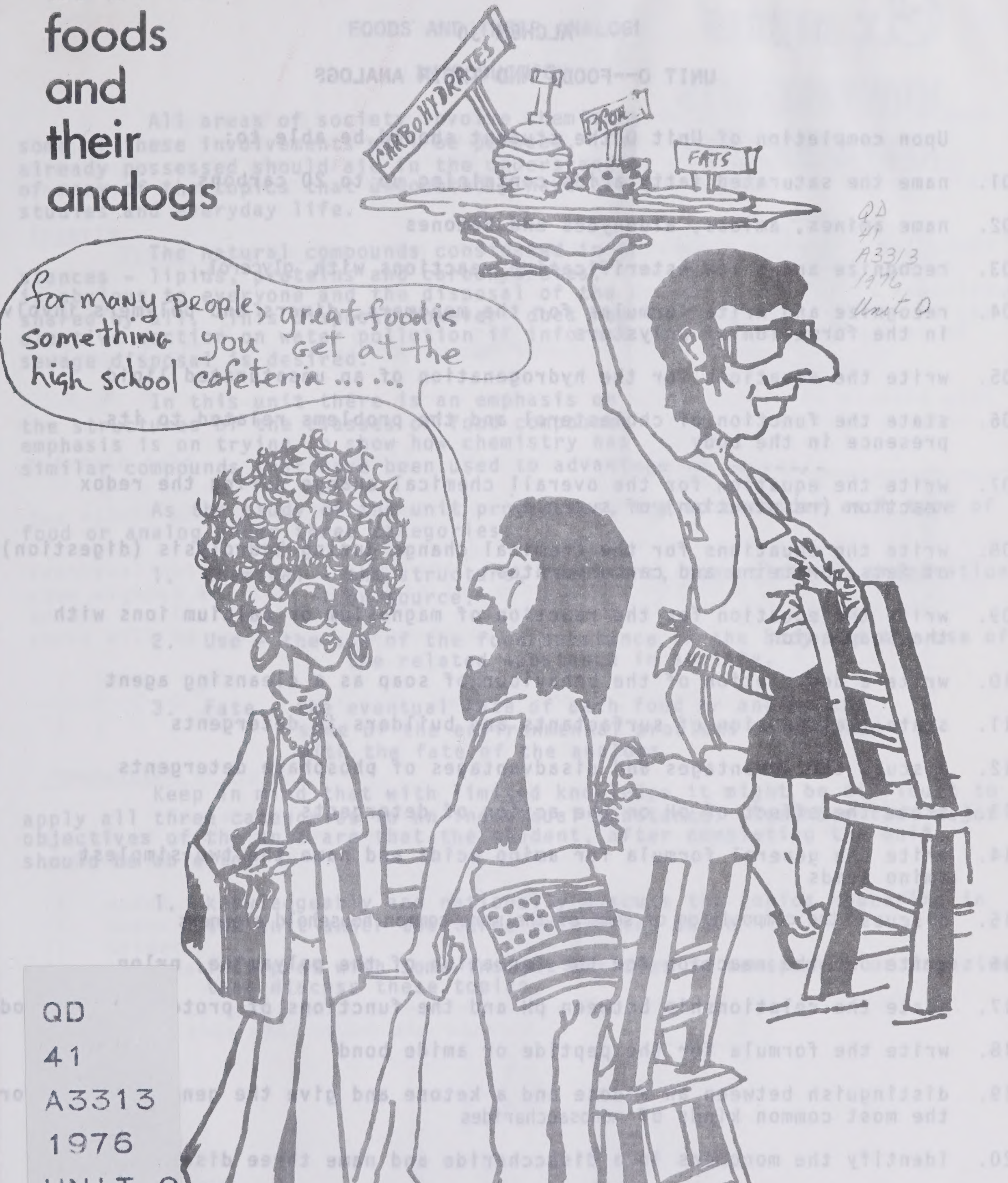
UNIT O
foods and their analogs


CARBOHYDRATES
PROT.
FATS
for many people, great food is something you get at the high school cafeteria......

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ALCHEM 30

UNIT O--FOODS AND THEIR ANALOGS

Upon completion of Unit O the student should be able to:

01. name the saturated fatty acids containing up to 20 carbons

02. name amines, amides, aldehydes and ketones

03. recognize and write esterification reactions with glycerol.

04. recognize and write formulas for the monomers, dimers and polymers involved in the formation of polysters

05. write the equations for the hydrogenation of an unsaturated lipid

06. state the function of cholesterol and the problems related to its presence in the body

07. write the equation for the overall chemical change during the redox reaction (respiration) of sucrose

08. write the equations for the chemical change during hydrolysis (digestion) of fats, proteins and carbohydrates

09. write the equation for the reaction of magnesium or calcium ions with the soap anion

010. write a description of the behaviour of soap as a cleansing agent

011. state the function of surfactants and builders in detergents

012. discuss the advantages and disadvantages of phosphate detergents

013. state the effect of pH on the action of detergents

014. write the general formula for amino acids and name the two simplest amino acids

015. discuss the composition of some of the more common household cleaners

016. write out the reaction for the formation of the polyamide, nylon

017. state the relationship between pH and the functions of protein in the body

018. write the formula for the peptide or amide bond

019. distinguish between an aldose and a ketose and give the general names for the most common kinds of monosaccharides

020. identify the monomers in a disaccharide and name three disaccharides

021. name two polysaccharides and be able to state the difference between them.

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FOODS AND THEIR ANALOGS

INTRODUCTION

All areas of society involve chemistry in some way. In this unit some of these involvements will be pursued. The knowledge of chemistry already possessed should aid in the understanding of the chemical aspects of many of the topics that undoubtedly have already arisen in biology, social studies and everyday life.

The natural compounds considered in this unit are the "food" substances - lipids, proteins and carbohydrates. The use of food in society is obvious to everyone and the disposal of the products is also an experience shared by all. This disposal however does result in sewage. Refer to the elective section on water pollution if information concerning problems of sewage disposal is desired.

In this unit there is an emphasis on acquainting the student with the structures of the classes of food compounds. Perhaps an even greater emphasis is on trying to show how chemistry has developed structurally similar compounds that have been used to advantage in society.

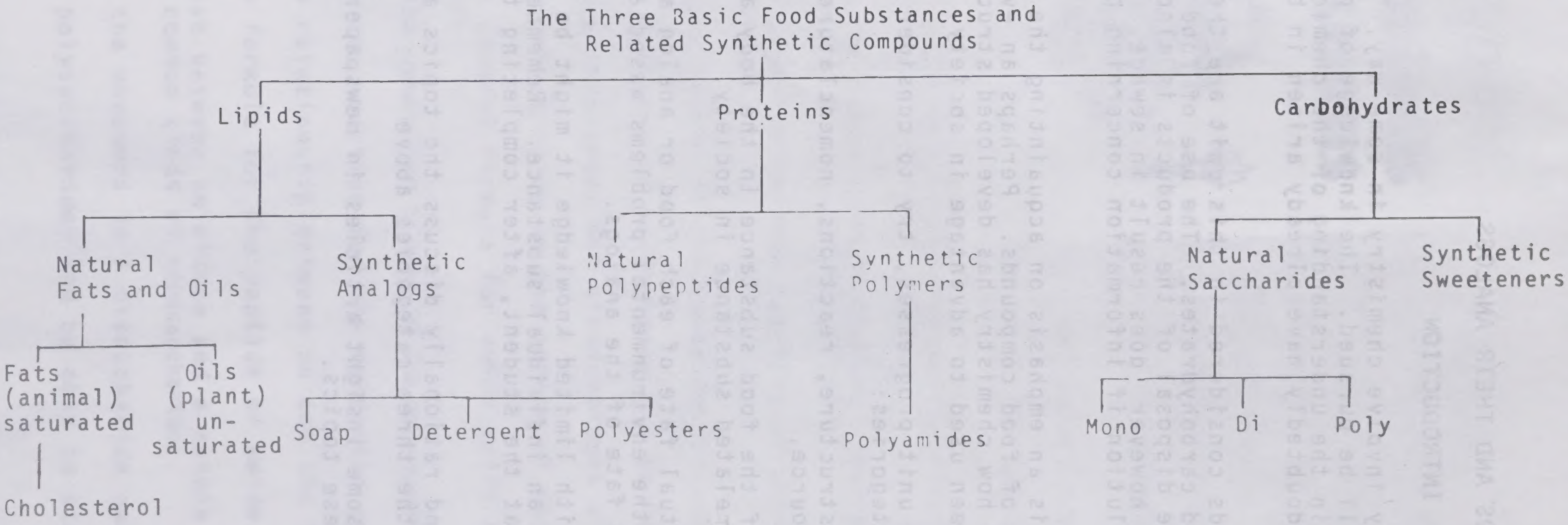
As the study of the unit progresses, try to consider each type of food or analog under three categories:

1. Chemical - the structure, reactions, nomenclature, preparation or source.
2. Use - the use of the food substance in the body and the use of the related substance in society.
3. Fate - the eventual fate of each food or analog and some of the environmental problems associated with the fate of the analogs.

Keep in mind that with limited knowledge it might be difficult to apply all three categories to an individual substance. Remember that major objectives of the unit are that the student, after completing the unit, should be able to:

1. knowledgeably and rationally discuss the topics appearing in the unit under the three categories above
2. interpret with some insight articles in newspapers or magazines that discuss these topics.

FOODS AND THEIR ANALOGS
FLOW CHART

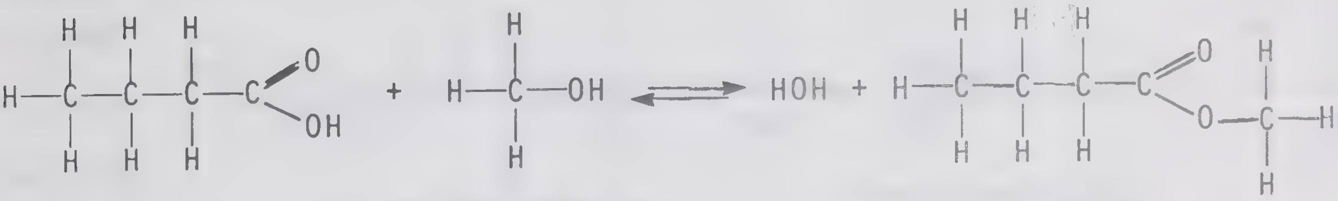


LIPIDS - ESTERS

Lipids (fats) are necessary substances for normal body functions. Most dietary lipids come from eating animal fats as in meat and butter and plant oils as in cooking oils. Lipids are esters and, like all esters, can be formed by the reaction between alcohols and acids.

Example:

Esterification Reaction: carboxylic acid + alcohol $\rightleftharpoons$ ester + water



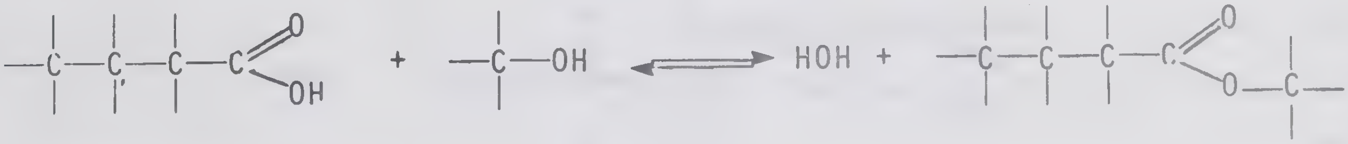
butanoic acid

methanol

methylbutanoate (the ester responsible for a pineapple's odor)

See *ALCHEM* Unit K for review of nomenclature of esters.

When writing structural formulas for larger compounds it is conventional not to show the hydrogen atoms. A line projecting from a carbon atom without any atom bonded to the other end represents a carbon-hydrogen bond. For the remainder of this course reactions like the esterification above will be written as shown below:



Nomenclature of Lipids

The majority of lipids involve carbon chains of well over 10 carbons. A list of prefixes for chains or 11-20 carbons is given below to help in understanding the names used in this unit.

11.	undec
12.	dodec
13.	tridec
14.	tetradec
15.	pentadec
16.	hexadec
17.	heptadec
18.	octadec
19.	nonadec
20.	eicos

Note: *It is not expected that you know the names of the compounds in this unit which are starred*(*).

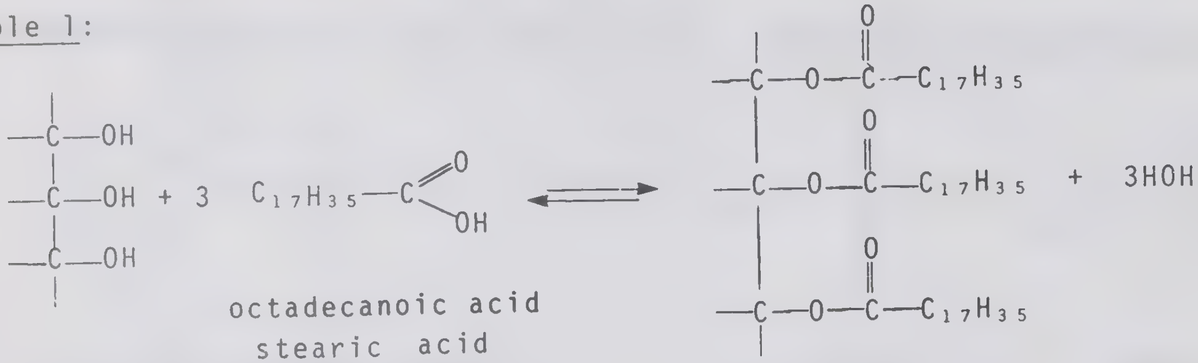
LIPIDS - ESTERS

Lipid Formation

An Example of Esterification

Lipids are distinguished from simpler esters in that they usually form from 1, 2, 3-propanetriol (glycerol) and a high molar mass fatty acid, materials present in most organisms.

Example 1:

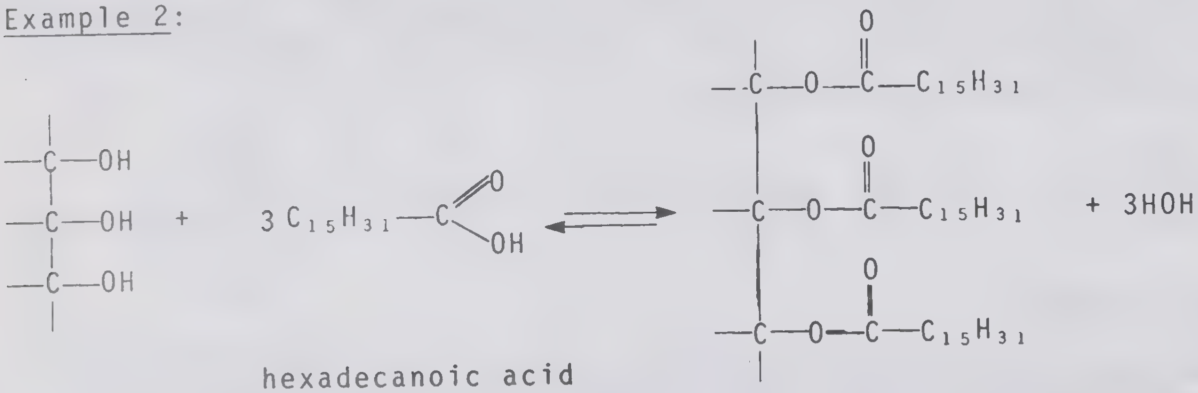


octadecanoic acid
stearic acid

1,2,3-propanetriol
or glycerol (commonly
called glycerine)

glyceryltrioctadeconoate
tristearin or glyceryltristearate*
(present in butter and lard)

Example 2:

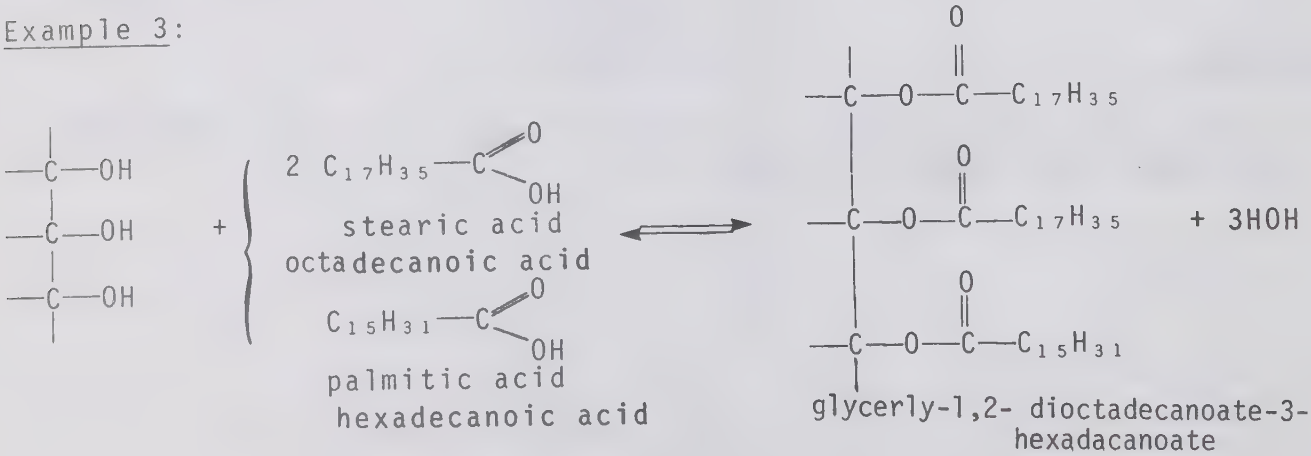


hexadecanoic acid
palmitic acid

1,2,3-propanetriol

glyceryltrihexadecanoate
tripalmitin* (present in palm oil,
butter and lard)

Example 3:



2 $C_{17}H_{35}COOH$
stearic acid
octadecanoic acid

$C_{15}H_{31}COOH$
palmitic acid
hexadecanoic acid

glycerly-1,2- dioctadecanoate-3-
hexadacanoate

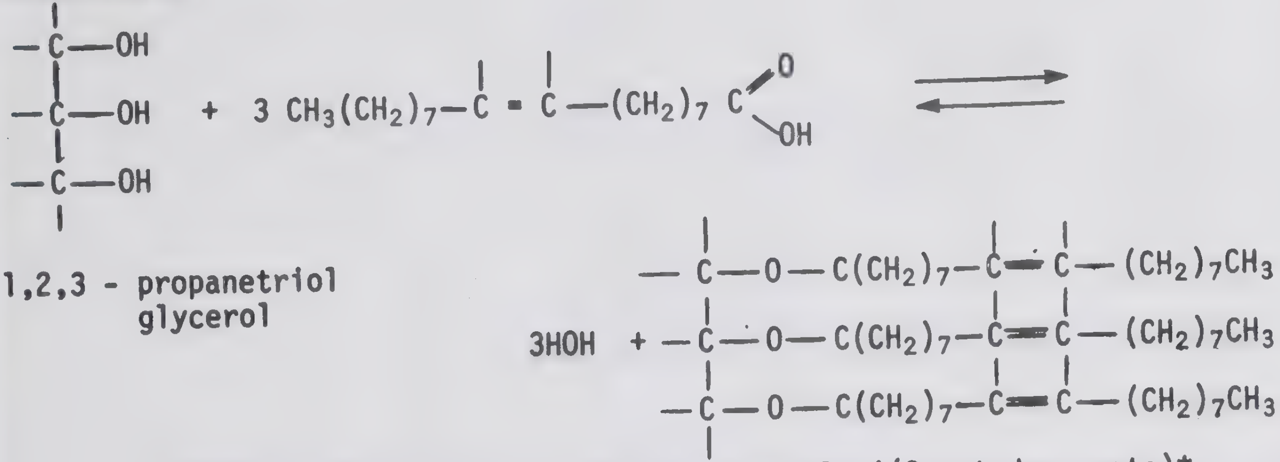
1,2,3-propanetriol

palmityldistearin*

LIPIDS - ESTERS

Most natural fats contain several different fatty acids (see Example 3). Most animal fats are saturated and are solids at room temperature Many plant fats are unsaturated (double or triple bonds). In some cases they are polyunsaturated (many double bonds). Most of these are liquids (oils) at room temperature.

Example 4:



1,2,3 - propanetriol
glycerol

glyceryltri(9-octadecenoate)*

triolein*

(present in Olive oil)

FOODS AND THEIR ANALOGS

LIPIDS - ESTERIFICATION

Write balanced structural equations for each of the following.

1. Butter fat (glyceryltributanoate) is formed by the esterification reaction of butanoic acid with 1,2,3-propanetriol (glycerol).

2. A component of linseed oil is produced when 9,12,15-octadecatrienoic aci (linolenic acid, $C_{17}H_{29}COOH$) reacts with glycerol.

LIPIDS - ESTERIFICATION

3. 9,12-octadecadienoic acid*(linoleic acid)($C_{17}H_{31}COOH$) reacts with glycerol in an esterification reaction to produce soybean oil.

4. Eicosanoic acid ($C_{19}H_{39}COOH$) reacts with glycerol to produce peanut oil.

POLYMERIZATION - POLYESTERS

The production of a lipid by a living organism can be represented by a fairly simple equation. If this simple reaction is capable of being repeated over and over a *polymer* results. *Polymerization* is the series of reactions joining many small molecules to make one large molecule. A *polymer* is made up of many small units

poly	means many
mer	means a small unit
mono	means one
di	means two

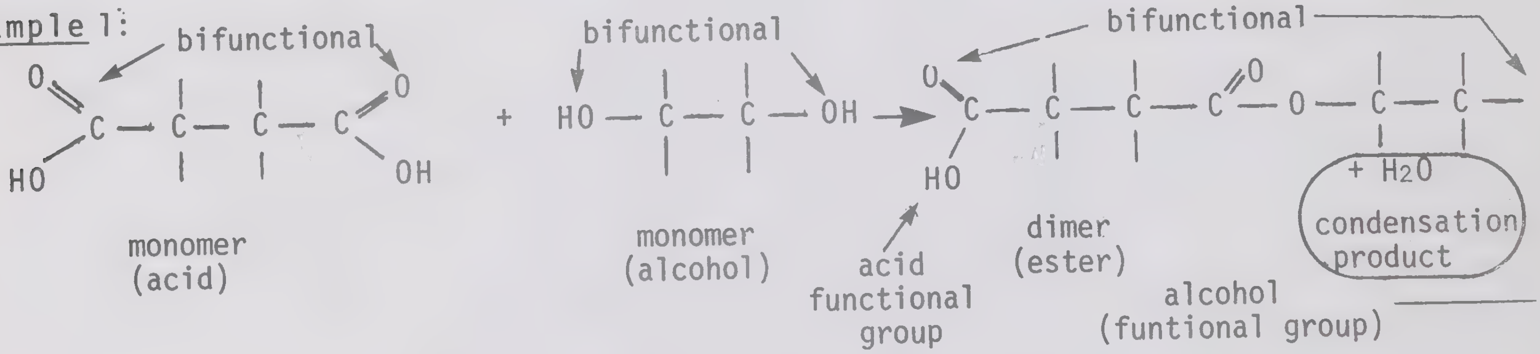
polymer - many small units
monomer - one small unit
dimer - two small units

There are two kinds of polymerization reactions.

1. Addition Polymerization These reactions involve alkenes and will be covered in the *ALCHEM* elective unit on ethylene.

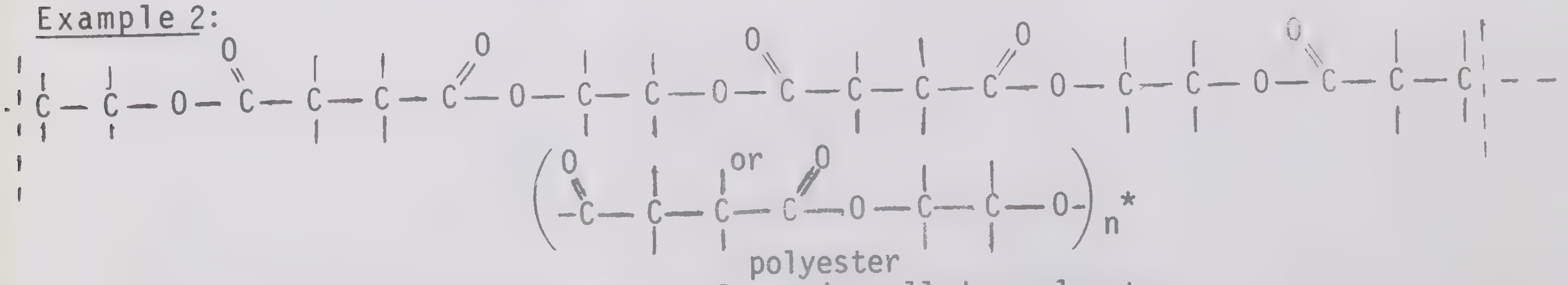
2. Condensation Polymerization In condensation polymerization a small unit (e.g., H_2O, HCl) is eliminated at each step of the reaction. This small molecule is said to be condensed out of the reaction. There are usually two different monomers in the reaction and each one is bifunctional, which means that each molecule contains two functional groups, both of which can react.

Example 1:



Once the dimer has been formed an acid functional group remains on one end and an alcohol functional group remains on the other end. Either of these groups can undergo an esterification reaction to add to the size of the molecule. Successive reactions result in a very large molecule, a polymer.

Example 2:

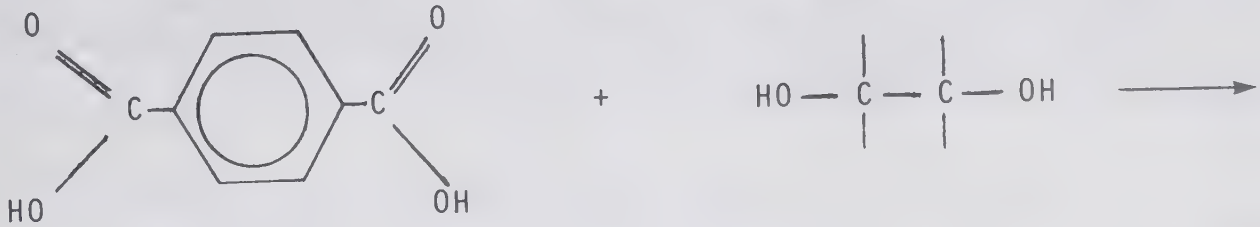


This particular type of polymer is called a polyester.

LIPIDS - POLYESTERS

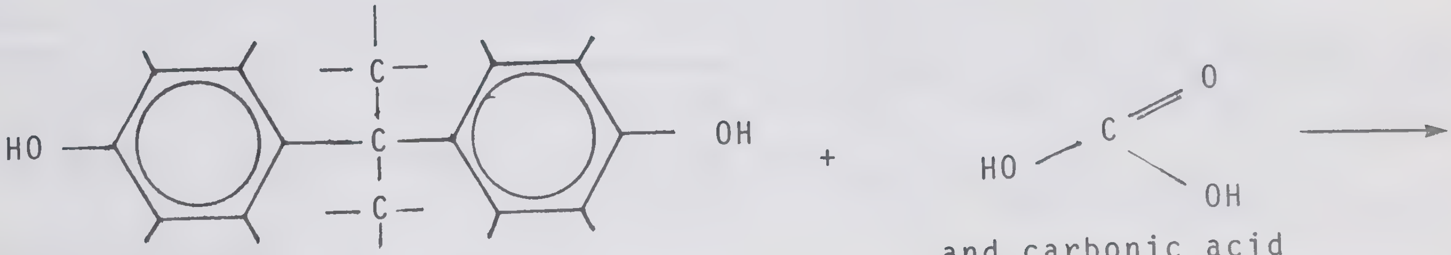
Write balanced structural formulas for the polymerization reactions. Write each one as a one step reaction to form the dimer. Then represent the polymer as the dimer taken n times (as in the example).

1.



1,4-benzenedicarboxylic acid*
(p-phthalic acid) and 1,2-ethanediol polymerize to make dacron.

2.



2,2-bis-(4-hydroxyphenyl) propane*

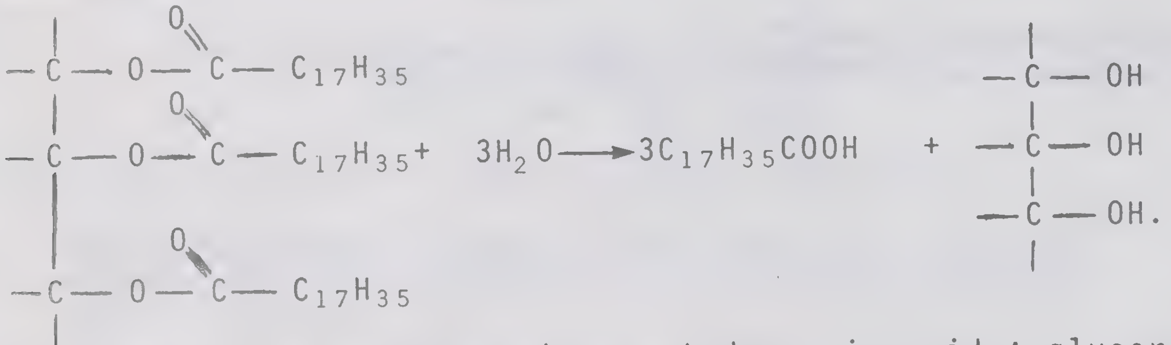
and carbonic acid react to form lexon

LIPIDS - DIGESTION AND RESPIRATION

Fats cannot be absorbed directly into the bloodstream because they are not water soluble. Fats must be digested first. *Digestion* is the breakdown of foodstuffs into simpler molecules which can be used by the body. The products of *digestion* of a fat are an organic acid and glycerol. This is the reverse reaction of *esterification* and is called *hydrolysis*. *Hydrolysis* is a decomposition reaction with water as a reactant.

Example:

Hydrolysis



glyceryltrioctadecanoate* ⟶ octadecanoic acid + glycerol

The glycerol and fatty acid products are then absorbed into the bloodstream and are either further broken down in *respiration* or are reconstructed as fats and stored in the body.

The *respiration* of fats is a process that generates much energy for the body but takes considerable time. *Respiration* is a stepwise oxidation-reduction reaction which occurs in the mitochondria of the cell to produce energy. The final products of this process are mainly carbon dioxide and water

Reconstituted fats form the energy reserve of the body which is stored as fatty tissue.

Cholesterol

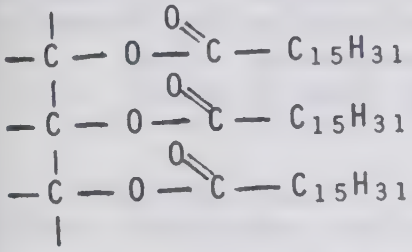
One of the more common reconstituted lipids in the body is cholesterol ($C_{27}H_{46}O$). Cholesterol is widely distributed in the human body. Much is found in nerve and brain tissue. Sometimes cholesterol is deposited in places where it creates problems. Gallstones are largely made up of cholesterol. Some people have large amounts of cholesterol deposited in the arteries and develop hardening of the arteries called *arteriosclerosis*.

It has been found that unsaturated lipids do not easily reconstitut as cholesterol. Thus people who have a tendency to develop cholesterol deposits are put on diets which are low in animal fats but oils are allowed.

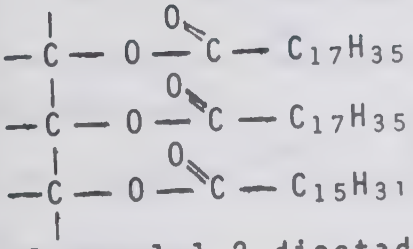
In general, however, fats are stored for energy reserves in subcutaneous (under the skin) layers which give the body its characteristic smooth curves and produce shapes which we all admire.

LIPIDS - HYDROLYSIS

Write balanced structural formulas for the hydrolysis (digestion) he following fats.



glyceryltrihexadecanoate*



glyceryl-1,2-dioctadecanoate-
-3-hexadecanoate*

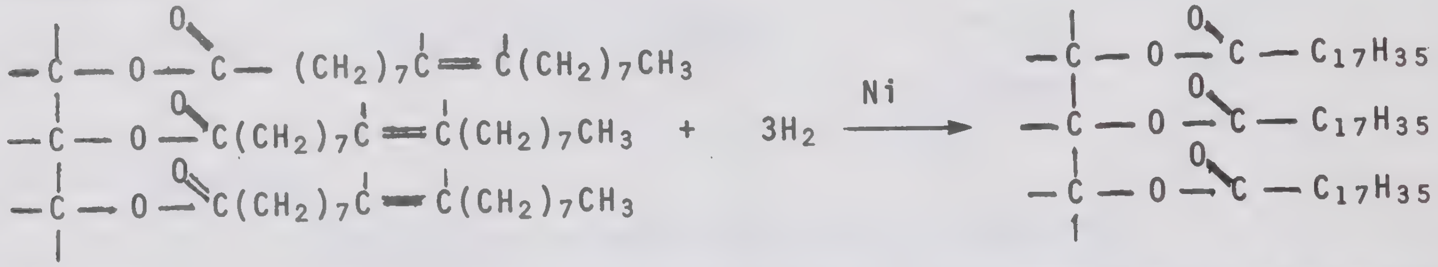
LIPIDS - DIGESTION AND RESPIRATION

Margarine

Unsaturated lipids can be saturated through the addition of hydr to the double bond, by a process called *hydrogenation*. By adding hydrogen t a controlled fraction of the double bonds, the melting point of the resultin fat can be set at any desired temperature. These hydrogenated fats mixed al with vegetable oils and animal fats are used to make margarine. Soft margarines contain larger amounts of unsaturated lipids than do hard margarines.

Hydrogenation reactions are extremely slow. Finely divided nickel added to the reaction system speeds up the reaction remarkably and is itself not consumed (i.e., nickel is a catalyst).

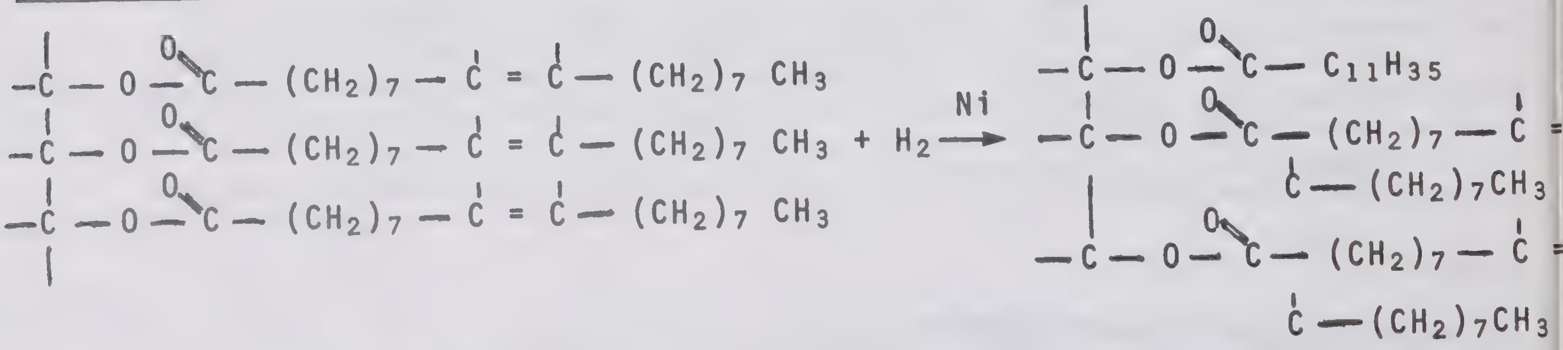
Example 1:



glyceryltri(9-octadecenoate)*

glyceryltrioctadecanoate*

Example 2:

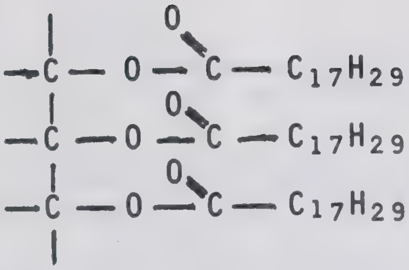


glyceryltri(9-octadecenoate)

glyceryl-1-octadecanoate
-2,3-di(9-octadecenoate)

LIPIDS - HYDROLYSIS

3.



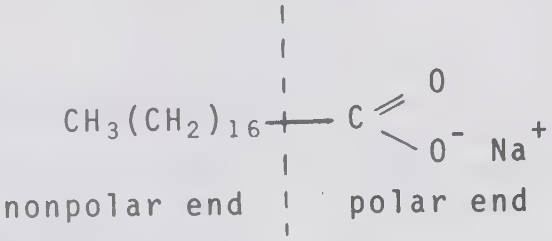
glyceryltri-(9,12,15,-octodecatrienoate)*

4. Hydrogenated lipids are generally solids at room temperature and are thus more easily handled. What would be a major disadvantage of hydrogenated lipids?

SOAPS

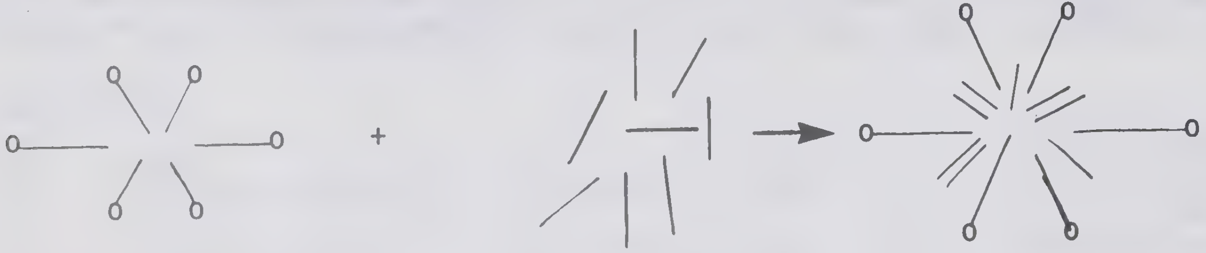
Soaps

Soaps clean by a mechanism that can be appreciated if solubilities are considered. Remember the rule that *like dissolves like.* Oil, grease and similar substances are usually nonpolar substances and therefore do not dissolve in polar water molecules. (Washing grease off hands using only water is a difficult task.) The soap molecule must bridge the gap between the polar water and the nonpolar grease. Part of the soap molecule is water soluble (polar or charged end) and part of the soap molecule is soluble in grease (nonpolar). The soap molecule ties the water and grease together. The grease dissolves in the nonpolar end of the soap molecule and the polar end of the soap molecule dissolves in the water.



$CH_3(CH_2)_{16}-C(=O)O^- \; Na^+$

The nonpolar ends of the soap molecule tend to group together with the polar ends extending into the water. This forms little round soap globules called *micelles.*



soap micelle

oil droplet

stabilized suspension of oil in soapy water

SAPONIFICATION - LAB 01

Purpose:

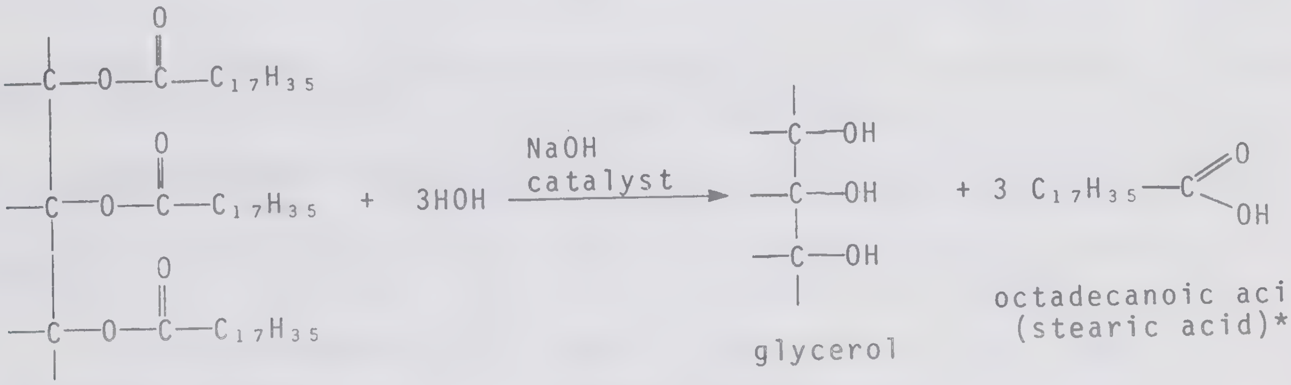
1. To produce soap from fat.
2. To test some of the properties of soaps.

Prelab information:

A lipid or fat is an ester made by reacting 1,2,3-propanetriol with a plant or animal fatty acid. In digestive processes the esterification reaction is reversed; i.e., the ester is first hydrolyzed (broken apart b water) to form the acids and glycerol (lipid + water ⇄ fatty acids + glycerol). In the organism (in vivo) catalysts (enzymes) are used to accelerate the reaction. Likewise the hydrolysis in the laboratory (in vitro) is catalyzed, usually with NaOH. The lye also reacts with the acids produced to transform them into their sodium salts (soap).

The fat used in this lab will be lard or grease. Although lard is actually a mixture of fats, for simplicity assume that it is mainly tristearin. The reaction can be written as a two step process.

Step 1: Hydrolysis

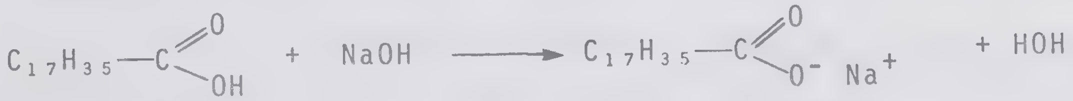


glyceryltrioctadecanoate
(tristearin*)

glycerol

octadecanoic acid
(stearic acid)*

Step 2: Neutralization



$$C_{17}H_{35}COOH + NaOH \longrightarrow C_{17}H_{35}COO^{-}\,Na^{+} + HOH$$

stearic acid
from Step 1

sodium stearate
(soap)

A family can react animal fat with lye (NaOH) to produce soap at home but this is rarely done today. It is much more efficient for a company to obtain fat from a large packing plant and process it commercially. A less harsh (less basic) soap can be produced and other materials (like perfume and cold cream) are added to make the product more attractive.

FOODS AND THEIR ANALOGS

SAPONIFICATION - LAB 01

Materials:

Day I:

1 - 250 ml beaker
1 - 100 ml beaker
1 - 75 mm evaporating dish
1 - stirring rod with rubber policeman
1 - scoopula
1 - pair crucible tongs
1 - bunsen burner
1 - 75 mm watch glass
23.0 g - lard or grease

3.4 g - NaOH (lye)
1 - 50 ml graduated cylinder
1 - wire gauze
1 - ring stand
1 - iron ring

Day II:

1 - wash bottle with distilled water
6 - 18 x 150 mm test tubes
10 ml - 1 M $Mg(NO_3)_2$
10 ml - 1 M $Ca(NO_3)_2$
a few drops light oil or kerosene
1 - scoopula
6 - #1 rubber stoppers

Procedure:

Day I:

1. Obtain 3.4 g of NaOH (lye) in a 100 ml beaker.

   Caution: NaOH is corrosive. Do not handle NaOH with hands.

2. Stir the lye into 15 ml of cold water in a 100 ml beaker until it dissolve and allow the solution to cool. (The dissolving of lye is exothermic.)

3. Obtain about 23.0 g of grease or lard in an evaporating dish.

4. Melt the grease in an evaporating dish and set it aside until nearly cool but still in liquid form or warm to the touch.

   Caution: Grease burns, use a low flame.

5. Slowly pour the dissolved lye into the grease. (NOT THE GREASE INTO THE LYE)

6. Stir slowly with a stirring rod until the mixture drops like honey from the stirring rod. Two to three drops of perfume may be added at this time.

7. Pour the mixture into a 250 ml beaker.

8. Cover the mixture with a 75 mm watch glass and store it overnight to allow the soap to solidify.

FOODS AND THEIR ANAOLOGS

SAPONIFICATION - LAB 01

Day II:

9. Using a scoopula flake the soap produced on Day I into each of 2 - 18x150 mm test tubes until the flakes are about 1 cm in depth. Fill the test tubes about half full with distilled water.

10. Stopper each test tube, shake it vigorously and observe. Record the observations.

11. Set the two test tubes aside and prepare three other 18x150 mm test tubes. Place 10 ml of 1 M $Mg(NO_3)_2$ into Test Tube 1, 10 ml of 1 M $Ca(NO_3)_2$ into Test Tube 2 and 10 ml of distilled water with a few drops of light oil into Test Tube 3.

12. Into a clean 18x150 mm test tube pour about 10 ml of the soap solution. Stopper and shake. Record the observations.

13. To each of Test Tubes 1 and 2 prepared in Step 11 add about 10 ml of the soap solution, stopper and shake. Observe the results. Record the observations after comparing to Step 12.

14. Stopper Test Tube 3 in Step 11 and shake. Observe the results and record the observations.

15. Using Test Tube 3, remove the stopper and add about 10 ml of soap solution. Stopper and shake. Observe the results and record the observations.

16. Discard all soap solutions and clean the test tubes with detergent. Note any which appear difficult to clea,. Record the observation.

Observations:

Day I:

mass of 100 ml beaker + NaOH __________ mass of evaporating dish + lard __________
mass of 100 ml beaker __________ mass of evaporating dish __________
mass of NaOH used __________ mass of lard __________

Day II:

Step 10 ______________________________
Step 12 ______________________________
Step 13 ______________________________
Step 14 ______________________________
Step 15 ______________________________
Step 16 ______________________________

SAPONIFICATION - LAB 01

Questions:

1. State two functions of NaOH in this reaction.

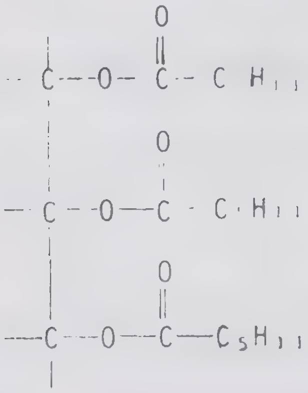
2. Does the soap produced form suds?

3. Hard water contains calcium and magnesium ions. Using the observations from the lab state the relative solubilities of magnesium and calcium stearates. How would this relate to the cleansing action of soap in hard water?

4. Outline some disadvantages of using this type of soap on a regular basis.

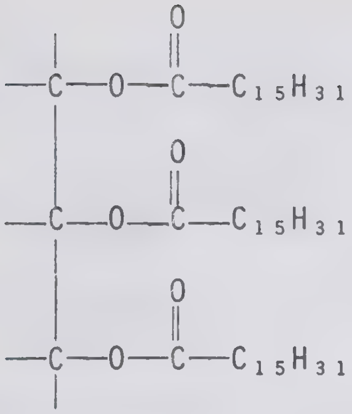
Write equations for the hydrolysis of the fats in Questions 5 - 7 and the equation for the neutralization reaction to form the soap. (Assume KOH is used in place of the NaOH used in the lab.

5.



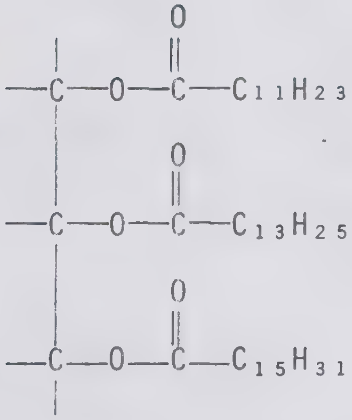
glyceryltrihexanoate

6.



glyceryltrihexadecanoate

7.



glyceryl-1-dodecanoate-2-tetradecanoate-3-hexadecanoate

8. Does the soap make the light oil more soluble in water? Explain.

Disadvantages of Soap

The soap produced in the laboratory had at least two disadvantages.

1. The soap was very harsh (basic) since the sodium hydroxide used in the preparation was not completely neutralized.
2. The soap would not clean well in hard water (i.e., water containing magnesium and calcium ions).
   a. The alkaline earth metals precipitate and remove the soap as insoluble stearates.
   b. The stearates mentioned in (a) above adhere to the substances being washed and leave a scum on the surface (the familiar bathtub ring).

$$\underset{\text{stearate ion}}{2C_{17}H_{35}COO^-} + \underset{\text{calcium ion}}{Ca^{2+}} \longrightarrow \underset{\text{calcium stearate (bathtub ring)}}{(C_{17}H_{35}COO)_2Ca}$$

DETERGENTS

Detergents

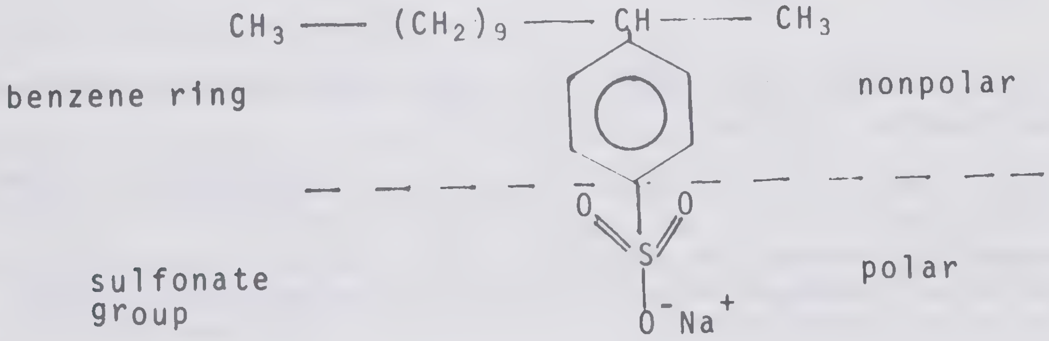
Detergents are an invention designed to simulate the action of soap but improve the performance. Detergents are called *syndets*, a term derived from *syn*thetic dergent*s*. Some requirements of modern detergents are that they:

1. must be biodegradable - capable of being broken down by bacterial action both in sewage treatment and in the environment
2. must be efficient as a cleaning agent
3. must not form scum or curd when combined with dirt or hard water (calcium and magnesium ions).

All modern detergents satisfy the above requirements. Detergents are composed of two major components, the surfactant and the builder. In addition, additives such as perfumes, brighteners, and antiredeposition agents are often used. A brief description of the components of detergents follows.

1. The Surfactant or Surface Active Ingredient

The surfactant component does the same job as soap. A commonly used surfactant is sodium dodecylbenzenesulfonate



Like soap, the surfactant is partially polar and partially nonpolar, but the polar end is more strongly polar than the comparable part of the soap molecule. Therefore the surfactant is more soluble in water and thus more effective in bringing the dirt into association with water. The surfactant mentioned above is an improvement over the first detergent surfactants which were not biodegradabl Early surfactants formed suds in the rivers and lakes even after sewage treatment. Water downstream from a major urban centre would come out of the tap with a *head*. Both soap and modern detergents are at least partially degradable although the aromatic ring of the surfactant may resist any change.

2. The Builder (Phosphates)

Builder as Sequestering Agent

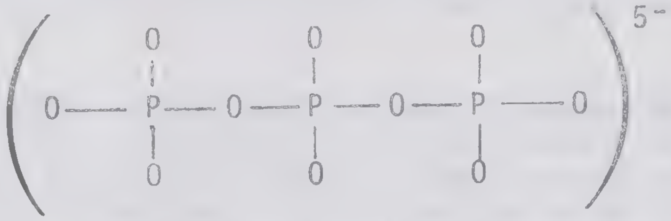
The main job of the builder is to condition the water so that the surfactant can work more effectively. One role of the builder is to complex or *sequester* Mg^{2+} and Ca^{2+} which would inhibit the surfactant. To sequester means to react with and remove from solution, but not to precipitate.

DETERGENTS

The builder that is almost universally used is a class of compounds called *phosphates*. The most popular compound used is *sodium tripolyphosphate*, $Na_5P_3O_{10}$, called STPP. In water the STPP dissociates to form the tripolyphosphate ion, (TPP).

$$\underset{\text{STPP}}{Na_5P_3O_{10}} \longrightarrow \underset{\text{TPP}}{P_3O_{10}{}^{5-}_{(aq)}} + 5Na^{+}_{(aq)}$$

The actual sequestering agent (builder) is the tripolyphosphate ion (TPP) which has the structure



$$\left(O-\overset{O}{\underset{O}{\overset{|}{\underset{|}{P}}}}-O-\overset{O}{\underset{O}{\overset{|}{\underset{|}{P}}}}-O-\overset{O}{\underset{O}{\overset{|}{\underset{|}{P}}}}-O \right)^{5-}$$

The TPP ion combines with any cations that may cause water hardness. The reaction can be represented as follows.

$$xP_3O_{10}{}^{5-}_{(aq)} + yCa^{2+}_{(aq)} + zMg^{2+}_{(aq)} \longrightarrow \underset{\text{soluble complex}}{Ca_yMg_z(P_3O_{10})_{x(aq)}}$$

The soluble complex produced remains in solution and thus prevents the Mg^{2+} and Ca^{2+} from forming insoluble compounds.

The TPP ion is biodegradable, which means that the ion can be taken in by organisms and broken down into substances which can be ingested by living organisms without harming the organisms. Biodegradable also means that the substance decomposes over time into natural substances. Being biodegradable does not mean being harmless to the environment. For example the TPP is degraded to the phosphate ion, $(PO_4)^{3-}(aq)$. The $(PO_4)^{3-}(aq)$ stimulates (fertilizes) the growth of algae and other aquatic plants. Any excess of the $(PO_4)^{3-}(aq)$ results in excessive amounts of algae growth which clog streams and create many other problems.

DETERGENTS

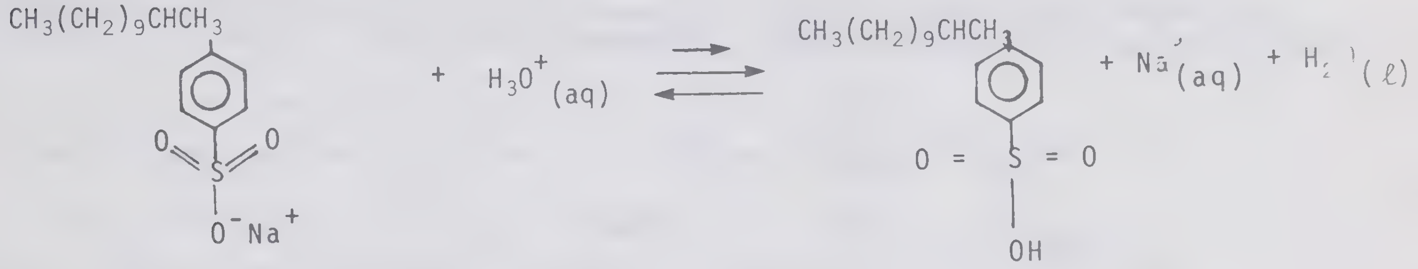
Builder as pH Regulator

A second role of the builder is to react with water to increase the hydroxide ion concentration.

$$P_3O^{5-}_{10(aq)} + H_2O_{(\ell)} \rightleftharpoons HP_3O^{4-}_{10(aq)} + OH^-_{(aq)}$$

Two reasons why wash water should be alkaline (high $[OH^-]$) are:

1. In an acidic solution the surfactant would not be ionic and therefore would not dissolve in water. For an explanation consider the equilibrium below:



   The equilibrium equation above shows the higher $[H\ O^+]$ shifting the equilibrium to the right to form *dodecylbenzenesulfonic acid.* The sodium dodecylbenzenesulfonate, the surfactant, has been removed from solution.

2. A basic solution is necessary to neutralize the acidic stains caused by perspiration.

Detergent Additives

1. Perfumes are often added to make the product more desireable.
2. Brighteners are organic dyes that absorb invisible ultraviolet light and emit visible blue and white light. This makes the wash look *whiter and brighter.*
3. Antiredeposition agents keep dirt and scum in suspension once they have been removed from the fabric. The dirt and scum are thus prevented from being redeposited.
4. Anticorrosion agents, foam boosters, and fillers such as Na_2SO_4 usually make up the balance of the detergent.

Table 01

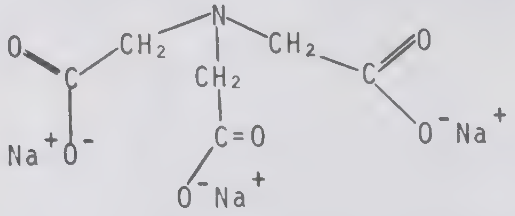
Composition of Typical Detergents

Ingredient	% by Mass
Surfactant	18.0
Builder	50.0
Perfume	trace
Whiteners, antitarnishing agents	0.9
Antiredeposition agents	3.0
Anticorrosion agents, foam boosters and fillers (Na_2SO_4)	approx. 28.0

DETERGENTS

In the last few years there has been a great deal of discussion concerning the use of phosphates and the associated problems of pollution. Unfortunately, there seems to be no satisfactory alternatives to the very efficient phosphate builder. Soap is no longer an alternative for detergents since the supply of fat to make the soap is inadequate. Also, the performance of soap in the washing machine is definitely inferior to that of detergents.

The most promising compound that emerged from research for a phosphate substitute was *trisodium nitrilotriacetate*, NTA.



NTA worked quite effectively but its use has since been banned. Research showed that NTA had a tendency to dissolve poisonous metals. Lead was leached out of pipes and copper from gaskets. These heavy metals were then transmitted by the expectant mother, who ingested the metals, to the unborn child. The presence of these heavy metals significantly increased the change of birth defects.

The question as to what is the actual composition of retail soaps and detergents may be of interest to some, especially when faced with the actual purchase of these compounds. Listed below are some examples of cleaners with their composition

Name of Substance	Builders $Na_5P_3O_{10}$ other phosphates	Surfactants Sulfonates & Sulfates	Soap	Other Compounds Builders & Fillers
Ivory Snow	-	-	75-100%	-
Tide	25-49%	20-42%	-	5-9%, Na_2SiO_3
Tide (no phosphate)	-	16-78%	-	10-24% Na_2SiO_3 10-24% Na_2CO_3
Camay	-	-	75-100%	5-10% fatty acid 1-4% cold cream
Lifebuoy	-	-	10%	1-10% perfume 1% germicide
Zest	-	16-37%	50-74%	1-4% chloride salts
Calgonite	100%	small amount	-	small amount NaOCl
Cascade	15-33%	10-24%		10-24% Na_2SiO_3
Hand Cleanser (waterless)	-	0-10%	10-30%	20-60% solvent (high flash naphtha)
Ajax	10%	6%	-	1% ammonia 3% Na_2CO_3
Mr. Clean	10-24%	5- 9%	-	5-9% Na_2CO_3 Amide 1 - 4%
PineSol	-	-	10%	10.9% isopropanol
Spic and Span	24-49%	-	-	50-74% sodium sesquecarbonate

LIPIDS - OVERVIEW

Review the section on lipids, polymers, soaps and detergents by answering the following questions.

1. Lipids are formed by the reaction between two classes of compounds, ______________________________ and ____________________________________.
The general name for a reaction of this type is ______________________.
The general class of compounds to which lipids belong is ____.

2. The common name of the compound most often used to make fats is ____.

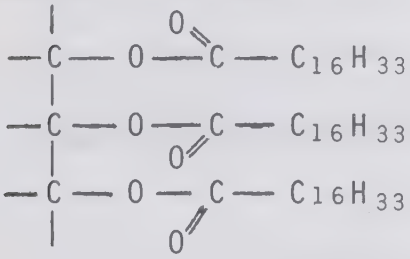
3. Describe the basic difference between animal fats and plant oils.
____

4. When many small molecules join together repeatedly, the result is a ____. A single molecule from which the large molecule is formed is called a ______________________________.
When two of the single molecules join together the result is a ____.

5. Whenever an acid and an alcohol both contain a bifunctional group they can react to produce a polymer called a ____________________________.

6. The digestion of a fat occurs by a chemical reaction called _________________________________ which is the reverse reaction to esterification.

7. Write the reaction for the digestion of



glyceryltrioctadecanoate

8. The stepwise oxidation reduction reaction which occurs in the body is called _________________________________.

9. State two problems which are caused by cholesterol in the body.

LIPIDS - OVERVIEW

10. State the three groups of compounds which are mixed together to form margarine.

11. What are the two main features of a catalyst?

12. What does the rule like dissolves like mean?

13. Explain the cleaning action of soap.

14. Catalysts within an organism are called ______________________________.

15. The soap produced in the lab leaves a scum on glassware. The ions responsible for this would most likely be ________________________
or ____________________________.

16. What does biodegradable mean?

17. The one ingredient in a detergent that does the job of soap is called
a ___________________________________.

18. The term *sequester* means ____
____.

19. A builder is necessary in a detergent for two reasons. The two reasons
are: (a) ____
____
and (b) ____

LIPIDS - OVERVIEW

20. A major disadvantage of the sequestering agent, STPP, is

____

____

21. Some detergents used to contain enzymes to help remove blood and other difficult stains. (It has since been learned that these enzymes in high concentration were harmful.) For best cleaning results should the enzyme be polar or nonpolar or both? Be prepared to defend your answer.

22. The carbonates which have been substituted for phosphates in detergents react appreciably with water, producing hydroxide ion. Write the Bronsted-Lowry equation for this reaction.

23. What will be the effect on the pH of the reaction in Question 22?

24. The carbonates mentioned in Question 22 are caustic enough to cause serious illness or death if eaten by a child. What implications would this have for a mother with young children?

25. Sodium carbonate (washing soda) is sometimes used to soften water so that soap can do its job more effectively. Write equations for the reactions that occur when the carbonate ion precipitates the hard water ions.

26. Discuss whether phosphates should be used in detergents. Include a discussion of the effects of removing phosphates (both good and bad), and some alternatives to phosphate detergents.

27. Suppose two shampoos were available, one with a $pH>7$ and another with a $pH<7$, which one would be the most effective cleaner?

AMINES AND AMIDES

Before discussing proteins it is necessary to become familiar with three classes of compounds known as amines, amides and amino acids.

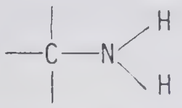
Amines

An amine is a compound in which the hydrogens or ammonia have been substituted for by hydrocarbon chains. The amines can be named by two systems.

1. Emphasizing the carbon chain and naming $-NH_2$ (amino) as a substituting group.

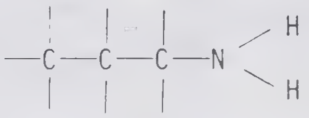
2. Emphasizing the amino functional group.

Example 1:



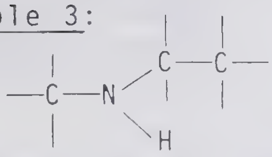
aminomethane
methylamine

Example 2:



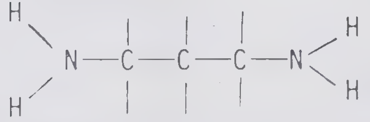
1-aminopropane
propylamine

Example 3:



methylethylamine

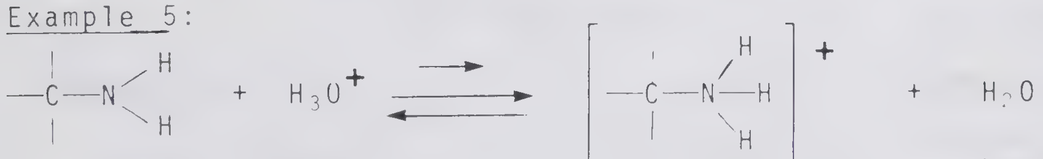
Example 4:



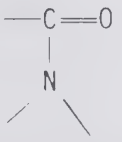
1,3-diaminopropane

Like ammonia, amines are Bronsted-Lowry bases; i.e., they are proton acceptors.

Example 5:



Another typical reaction of amines is the production of *amides* from carboxylic acid. The amide functional group consists of a carbonyl group bonded to a nitrogen,

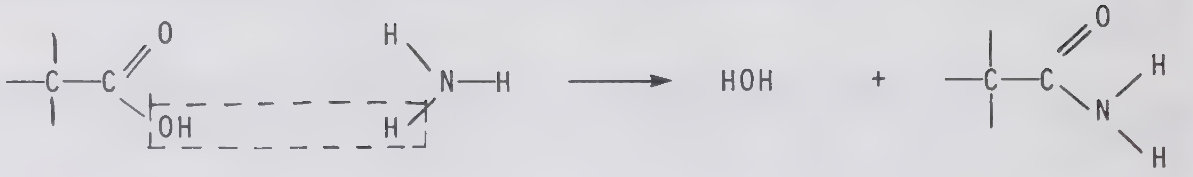


, and is also called an amide link or peptide link. If the acid reacts with ammonia, a *simple* amide results. If the acid reacts with an amine, an *N-substituted or nitrogen substituted* amide results as the two examples below indicate.

AMINES AND AMIDES

Example 1:

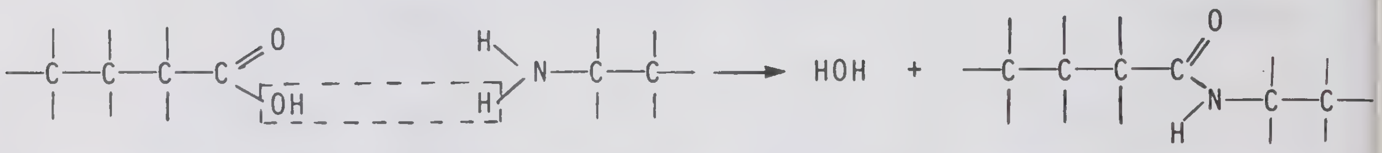
an acid + ammonia ⟶ water + an amide



ethanoic acid ammonia water ethanamide

Example 2:

an acid + an amine ⟶ water + an amide



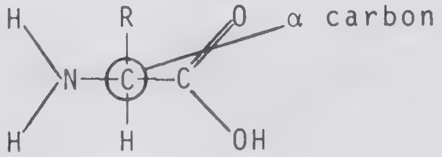
butanoic acid aminoethane water N-ethylbutanamide
(N-ethyl refers to
having an ethyl group
bonded to the nitroge
atom of the amide bon

Amino Acids

Amino acids are bifunctional (2 different functional groups) compounds containing the functional groups of both acids and amines. All amino acids have similarities in structure. They are composed of a central carbon atom called the alpha (α) carbon which is bonded to:

1. an hydrogen atom
2. a carboxyl group
3. an amino group
4. one other atom or group of atoms.

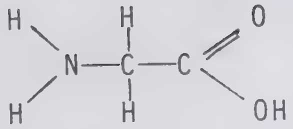
Example 1:



general formula for all amino acids

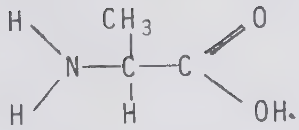
The R group, bonded to the alpha carbon, gives the 20 different naturally occurring amino acids their identifying properties.

Example 2:



glycine (R group is an H atom - the simplest amino acid)

Example 3:

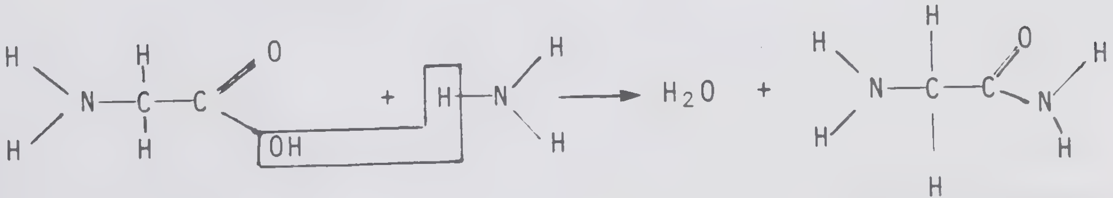


alanine (R group is a methyl group)

Note that most amino acid names end in *ine*.

Since amino acids are acids they can react with amines. Since they are also amines they can react with acids. In each case an amide bond or peptide bond results.

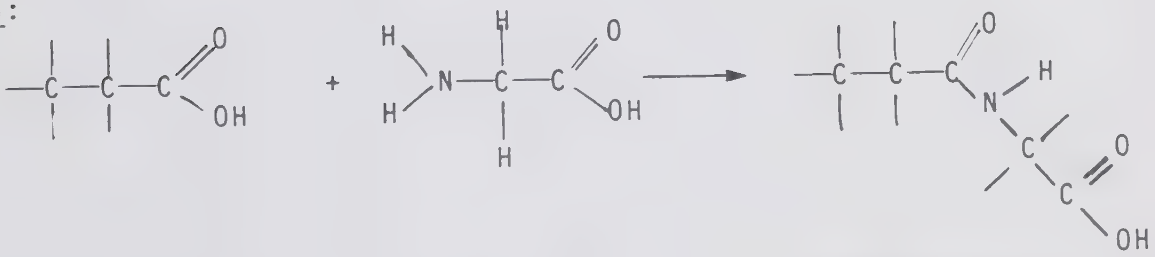
Example 4:



glycine
aminoacetic acid

aminoacetamide

Example 5:



propanoic acid

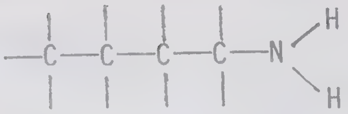
glycine

complex amide

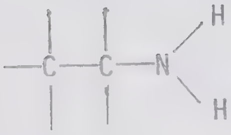
AMINES AND AMIDES

Name the following substances.

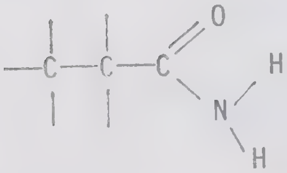
1



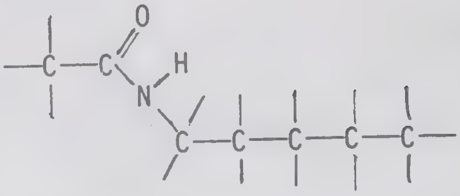
2.



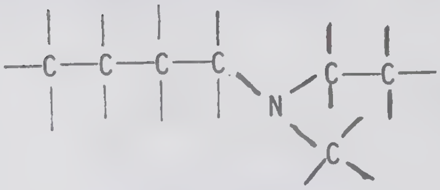
3.



4.



5.



Do the following question by writing structural equations for the reactions.

6. pentanoic acid plus ammonia

AMINES AND AMIDES

7. propanoic acid plus methylamine

8. alanine plus methyamine

9. alanine plus methanoic acid

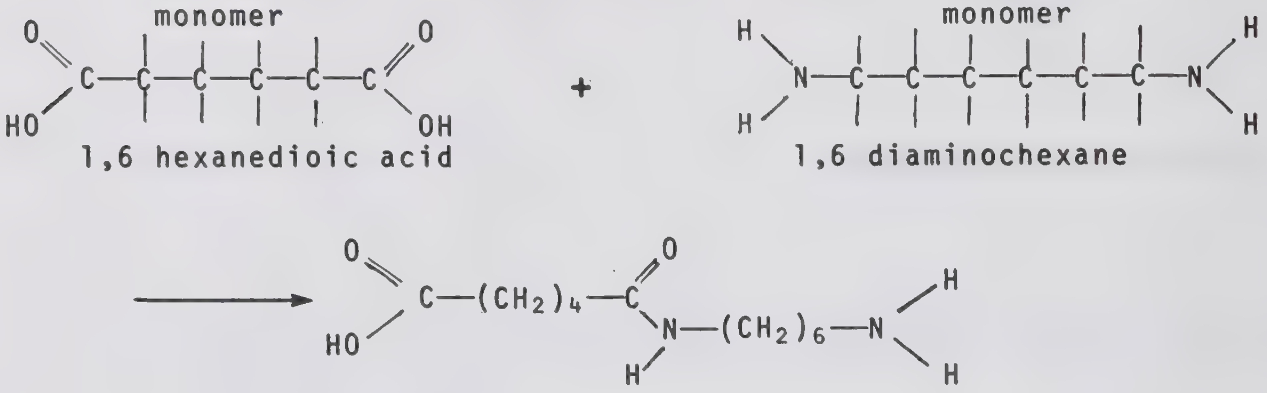
PROTEINS - SYNTHETIC POLYMERS

The reaction between an amino group and an acid group results in water as a condensation product. Substances which are bifunctional acids reacting with substances which are bifunctional amines will form polymers.

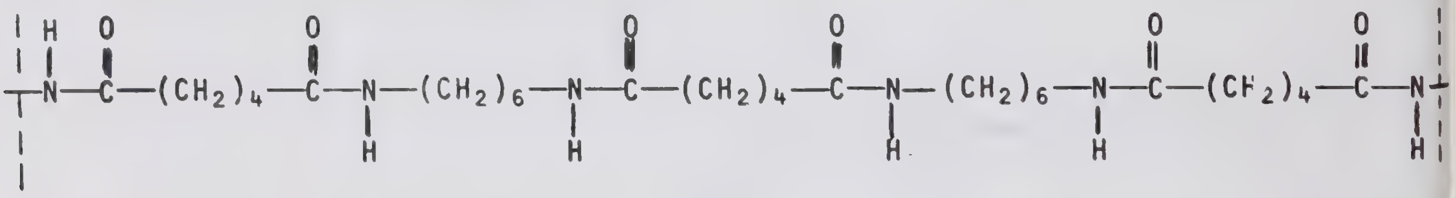
Some very useful polymers have been synthesized using the above reaction. Notice that the monomers are joined together by amide (peptide) bonds.

Example:

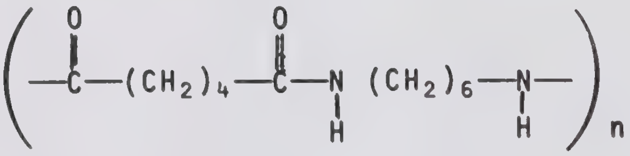
acid + amine ⟶ amide + water



Since the dimer above is bifunctional, continued reaction can occur to form the polymer, *nylon 6-6*.



or



$$\left(-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-\underset{H}{\underset{|}{N}}\ (CH_2)_6-\underset{H}{\underset{|}{N}}-\right)_n$$

FOODS AND THEIR ANALOGS

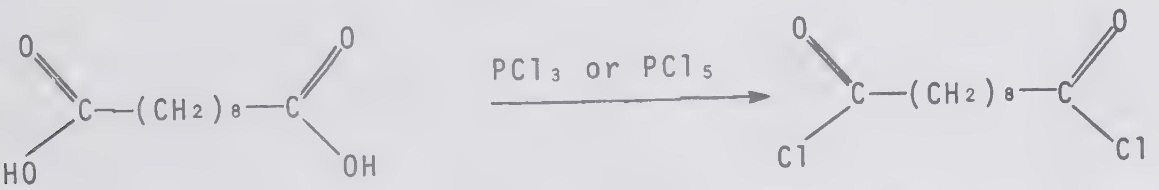
PRODUCTION OF NYLON - DEMO 01

Purpose:

To demonstrate the production of a polymer.

Prelab Information:

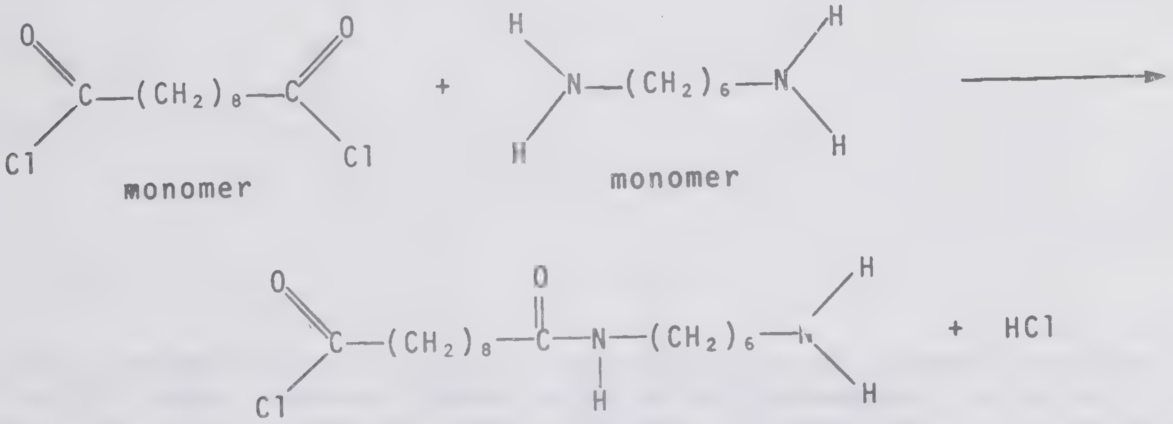
There are a variety of different nylons obtained by using slightly different monomer units. Nylon 6-6, with both monomers having six carbons, is made from 1,6-diaminohexane and adipic acid. Another nylon, Nylon 6-10, is made from 1,6-diaminohexane (6 carbons) and decanedioic acid (10 carbons). To make this reaction occur at a faster rate the decanedioic acid is modified to give an acid chloride called sebacyl chloride.



1,10-decanedioic acid
(sebacylic acid)

sebacyl chloride

The sebacyl chloride is then reacted with 1,6-diaminohexane to produce the amide.



(a dimer)

The repeated reaction of sebacyl chloride and 1,6-diaminohexane produces Nylon 6-10.

Procedure:

1. Dissolve 1.5 ml of sebacyl chloride in 50 ml of tetrachloroethene contained in a 150 ml beaker.
2. Dissolve 2.2 g of 1,6-diaminohexane in 25 ml of distilled water contained in a 100 ml beaker.
3. Carefully pour the amine solution over the acid chloride solution without mixing the two solutions.
4. Using tweezer, grasp the polymer film formed at the interface and pull the nylon out. If the rope is to be handled, make sure it is rinsed well with water to remove all the acid chloride. A roller made from an old paper towel cardboard tube can be used to roll the nylon on.

PRODUCTION OF NYLON - DEMO 01

Questions:

1. Explain the difference between nylon 6-6 and nylon 6-10.

2. If the polymer, nylon 10-10 were to be made, what would be the formulas for the two monomers involved?

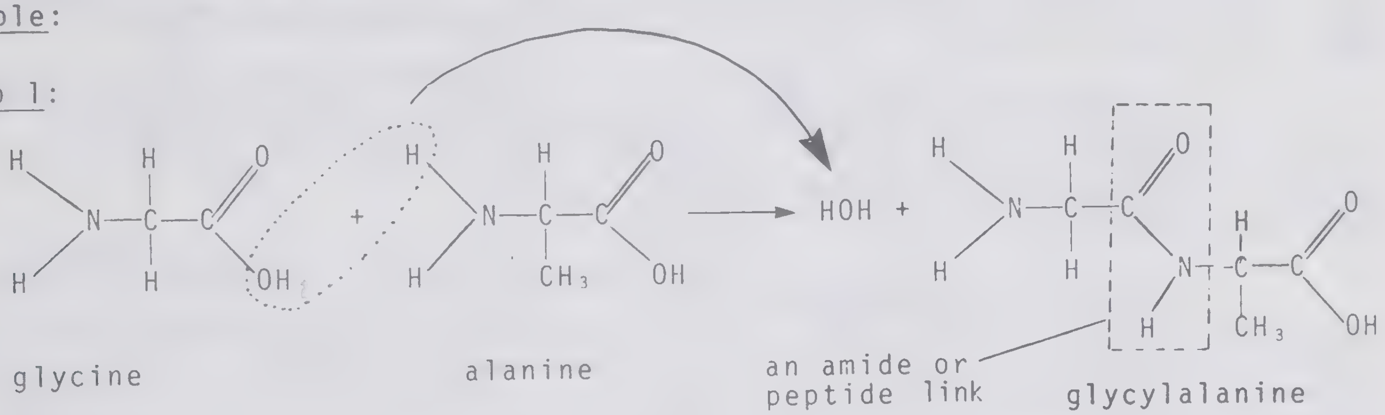
3. The polymer strands in nylon are each only a few millimetres long, yet the strands in the demonstration were several metres long. Recalling the *ALCHEM* unit on chemical bonding, speculate on the type of intermolecular bonding present in nylon.

PROTEINS

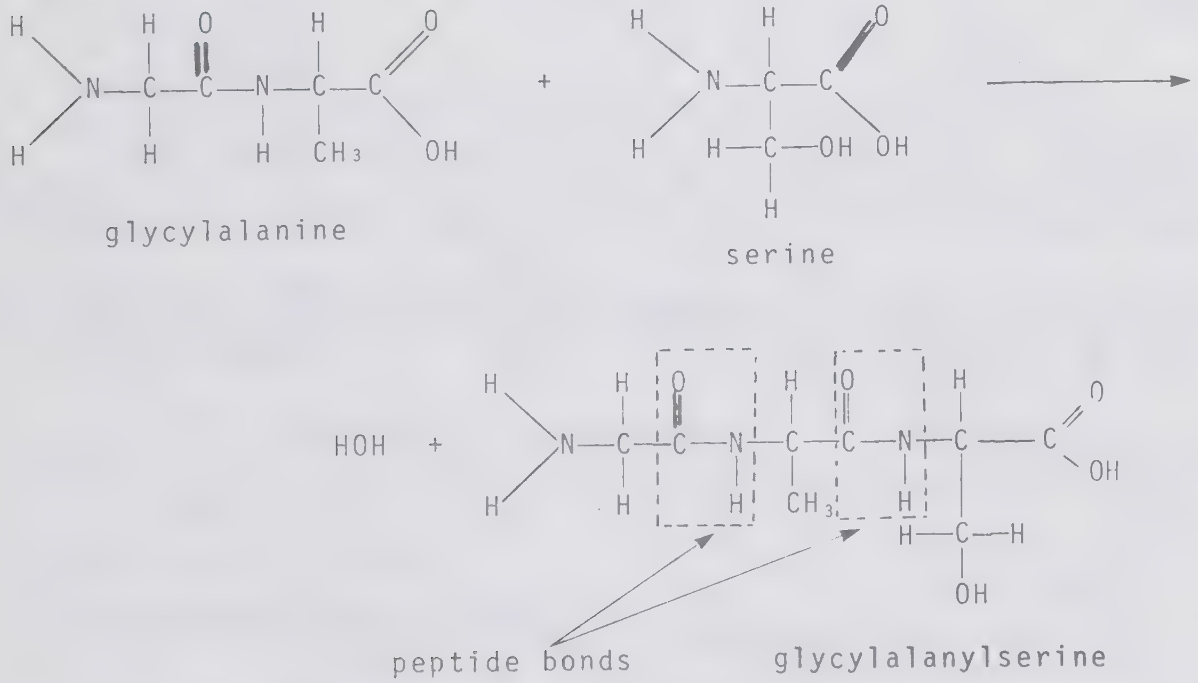
In nature the most common reaction of an amino acid is with another amino acid (the amino group of one compound reacting with the carboxyl group of another). When this type of reaction is repeated many times on the same amino acid segment, a chain of amino acid residues is produced. If the molar mass of the chain is large enough (roughly 5000 to several million grams per mole) the long chain molecule is called a protein. Large molecules (macromolecules) formed in this manner are called *polymers*. The following series of equations is an example of the initial steps in the polymerization of amino acids into a protein.

Example:

Step 1:



Step 2:



Note that a peptide bond is only an amide bond but since it forms specifically between amino acids (rather than any amine and any acid) it is given a special name. If the polymerization were continued, a *polypeptide* would form. If polymerization were continued long enough a protein would result.

PROTEINS

Proteins

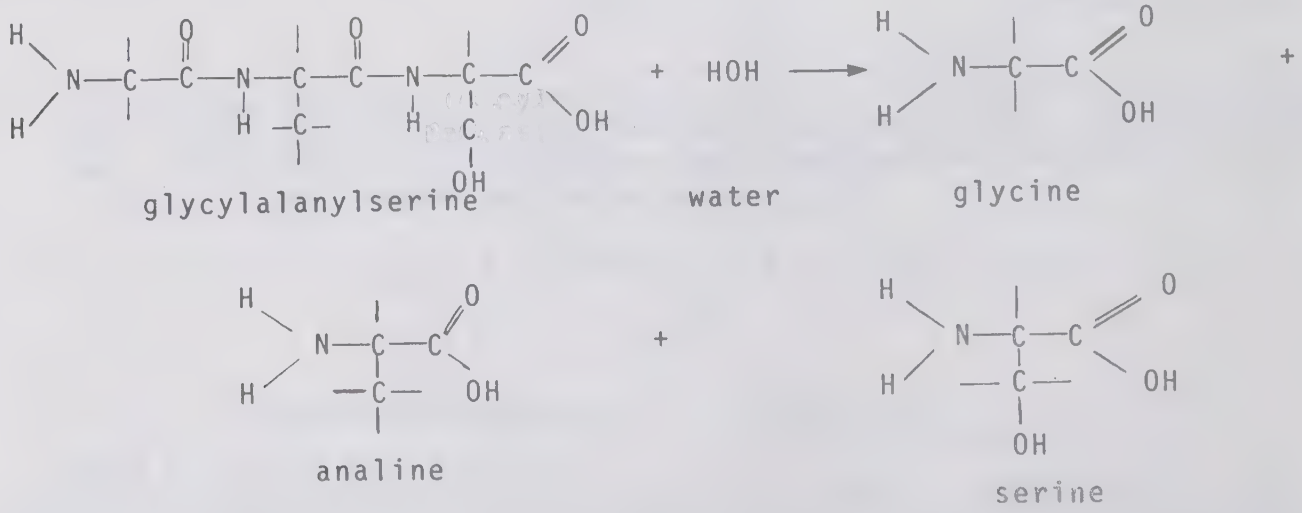
Proteins are essential in living systems and are usually ingested in the form of meat. However, cheese, soyabean, rapeseed, fish and some other substances are a good *source of protein*. Only the amino acids are essential and any food that contains amino acids is a "source of protein ". The food does not have to be a protein. A solution containing all the amino acids in one mixture would be a good "source of protein ". Milk is a good protein source since it contains all the common amino acids and is rich in the essential ones. The body can synthesize some amino acids. The ten amino acids that the body cannot synthesize are called *essential* because they *must* be in the diet.

Proteins are not only important structural substances in living systems (connective tissues, hair, nails, skin, bone, muscle) but many proteins act as *catalysts*. Catalysts are compounds that increase the rate of a chemical reaction without being consumed by the reaction. Proteins that are catalysts are called *enzymes*.

The enzyme insulin is a well known catalyst. Without insulin the body cannot metabolize sugars quickly. It is an amazing feat to synthesize an insulin molecule. Fifty-one amino acid residues must be bonded in a specific sequence and with a specific three dimensional shape to form insulin. Yet this enzyme, like thousands of others in living systems, is constantly being synthesized. Some of these enzymes contain thousands of amino acids bonded in a specific order! To pursue the topic of proteins further consult elective unit

Digestion

Proteins, like fats, cannot be absorbed into the blood stream. They must be digested. The *digestion* of proteins is a hydrolysis reaction in which water is added to the protein and the peptide bond breaks apart forming the constituent amino acids.

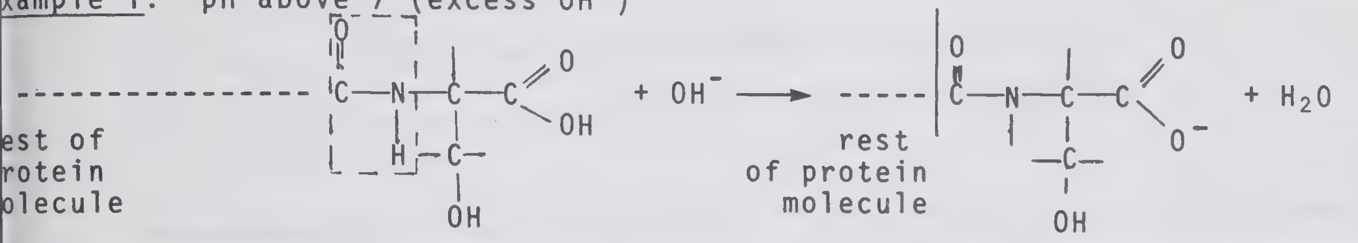


The resulting amino acids are absorbed into the blood stream, aken to the individual cells and reconstituted to make up body protein. ost protein material is used by the body in this manner. Only a very small mount of the body's energy comes from the respiration of protein.

H Dependency

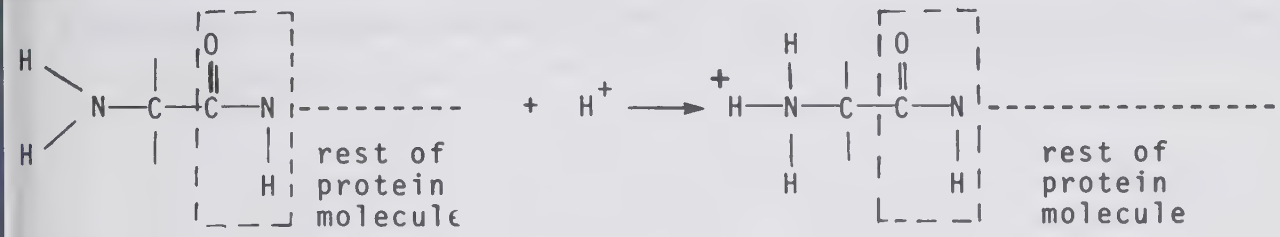
Protein molecules contain many basic and acid groups. Varying the H will vary the ionization and charge on the protein molecule.

xample 1: pH above 7 (excess OH^-)



--- serine ---serinate water

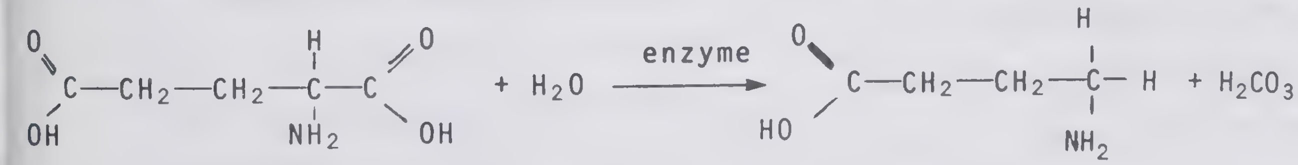
xample 2: pH below 7 (excess H^+)



glycyl ---

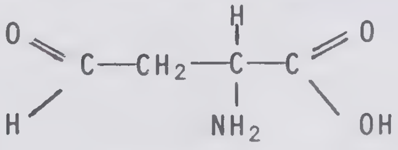
hese seemingly minor changes cause a major change in the ability of the rotein to carry out its function.

A good example of this is the action of enzymes (catalysts which peed up biochemical reactions). These enzymes are proteins and are very pecific in their action.



glutamic acid

The enzymε will not catalyze the same reaction with



aspartic acid

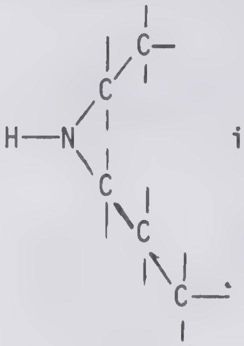
Any small change in the enzymes shape or charge will render it effective. Thus for a protein to carry out its function the pH of the stem must be controlled within very strict limits.

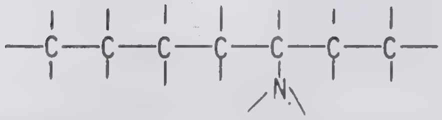
PROTEINS - OVERVIEW

Review the section on proteins by answering the following questions.

1. The structural formula for 2-aminopentane is ______________________.

2. The structural formula for 2-ethyl-1-aminohexane is ________________.

3. The name of  is ____.

4. The name of  is ____________________.

5. Amines, like ammonia, are Bronsted-Lowry *acids or bases?* (Circle one.)

6. Draw a *Lewis formula equation* to show how methylamine reacts in Question 5.

7. N-propyl octanamide is produced in a reaction between the two compounds (give names and formulas) ____

   __________________________ and ____________________________________.

8. Write a structural formula equation to show the production of the simple amide, acetamide.

9. Write a structural formula equation to show the production of the N-substituted amide, N-methylpropanamide.

PROTEINS - OVERVIEW

10. The term *alpha carbon* refers to the carbon atom that is part of the carboxyl group. True or false? ____________

11. Nylon 6-6 is made up from two monomers. These are ____________________ and ________________________.

12. Polymerization of amino acids *eventually* results in the production of a ________________________________ if the molecule is large enough.

13. Amino acids are linked together in macromolecules by a link known as the ______________________________ link or the __________________________ link.

14. The *ine* suffix usually indicates the compound is a(n) __________________

15. All proteins are polypeptides and all polypeptides are proteins. True or false? ____________. Explain. ______________________________
____
____

16. Some foods that are considered good sources of protein are ______________, ______________, ________________, ________________, ____________________.

17. Discuss the statement: *It is important to eat foods rich in protein.*

18. Proteins that act as catalysts are called __________________________.

19. Some structural materials in the human body that are rich in protein are ____________, _______________, ________________, ________________.

CARBOHYDRATES - ALDEHYDES AND KETONES

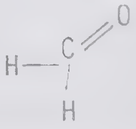
Carbohydrates contain functional groups which are either *aldehydes* or *ketones*. Both aldehydes and ketones contain the *carbonyl* group (C = 0). The carbonyl group can be attached in either a primary position (i.e., bonded to only one other carbon) or in a secondary position (i.e., bonded to only two other carbons). The carbonyl group can never be in a tertiary position (i.e., bond to only three other carbons). When the carbonyl group is in the primary position the substance is an aldehyde (*alkanal*) and when in a secondary position is a ketone (*alkanone*).

Aldehydes (Alkanals)

Aldehydes are named according to the following system.

Drop the *e* from the alkane name and add *al*.

Example 1:

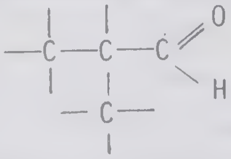


menthan*al*

aldehyde suffix

common name - formaldehyde

Example 2:



2-methylpropanal

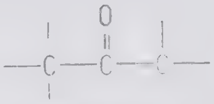
Note the primary position of the carbonyl group.

Ketones (Alkanones)

Ketones are named according to the following system.

Drop the *e* from the alkane name and add *one*.

Example 1:

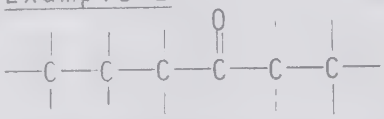


propan*one*

ketone suffix

common name - acetone

Example 2:



3-hexanone

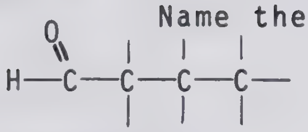
Note the secondary position of the carbonyl group.

CARBOHYDRATES - ALDEHYDES AND KETONES

Questions

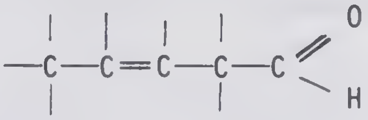
Name the following compounds.

1.



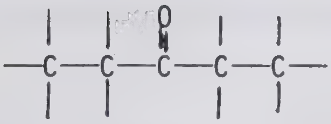
$H-\overset{\overset{O}{\|}}{C}-C-C-C-$

2.



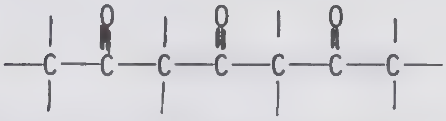
$-C-C=C-C-C\begin{smallmatrix}/\!/ O\\ \diagdown H\end{smallmatrix}$

2.



$-C-C-\overset{\overset{O}{\|}}{C}-C-C-$

4.



$-C-\overset{\overset{O}{\|}}{C}-C-\overset{\overset{O}{\|}}{C}-C-\overset{\overset{O}{\|}}{C}-C-$

Draw structural formulas for the following compounds.

5. 2-hexanone

6. pentanal

7. 3-methyl-2-butanone

8. 2,3 -dimethylbutanal

9. butanedial

10. 2,3-pentanedione

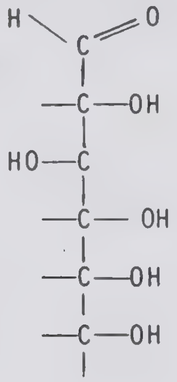
CARBOHYDRATES - NATURAL SACCHARIDES

Carbohydrates are organic compounds that have the general formula $C_x(H_2O)_y$. Carbohydrates are referred to as *saccharides* and can be categorized as follows:

carbohydrates
- monosaccharides (one monomer)
- disaccharides (two monomers)
- polysaccharides (many monomers)

Monosaccharides

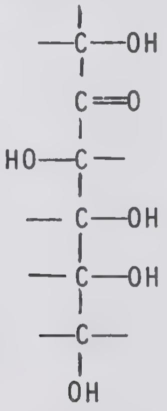
There are a good many common monosaccharides. One of these is glucose which has the following structure.



glucose

Glucose is an aldehyde and is therefore a member of the group of sugars called *aldoses* because they contain aldehyde groups.

Another monosaccharide is fructose.



fructose

CARBOHYDRATES - NATURAL SACCHARIDES

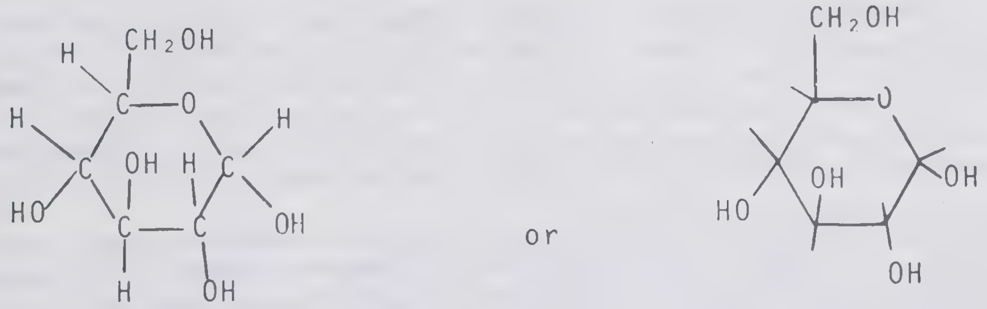
Fructose is a ketone and is therefore a member of the group of sugars called *ketoses* because they contain ketone groups.

The monosaccharides have the general formula $C_x(H_2O)_x$ where x can have values from 3 to 7, but the pentoses (5-carbon sugars) and hexoses (6-carbon sugars) are most common. Glucose ($C_6H_{12}O_6$) and fructose ($C_6H_{12}O_6$) being the two most common hexoses, will be used in this unit.

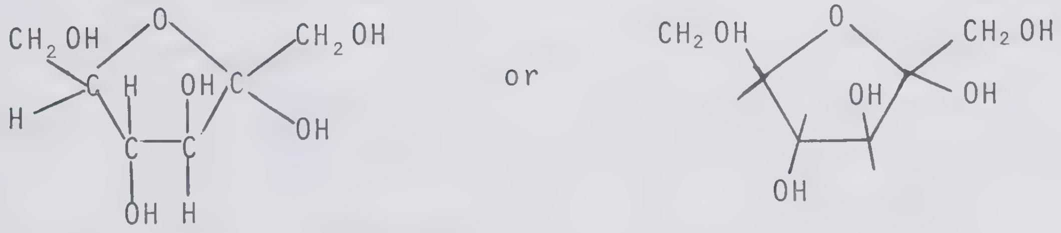
Structure and Nomenclature of Monosaccharides

Sugars are generally given common names. Saccharides are not named as simple aldehydes and ketones for two reasons.

1. Saccharides also contain the alcohol functional group.
2. The structure shown for glucose and fructose may be adequate for the solid substances. In solution the configuration changes to a much more complicated cyclic arrangement. Simplified diagrams are shown below.



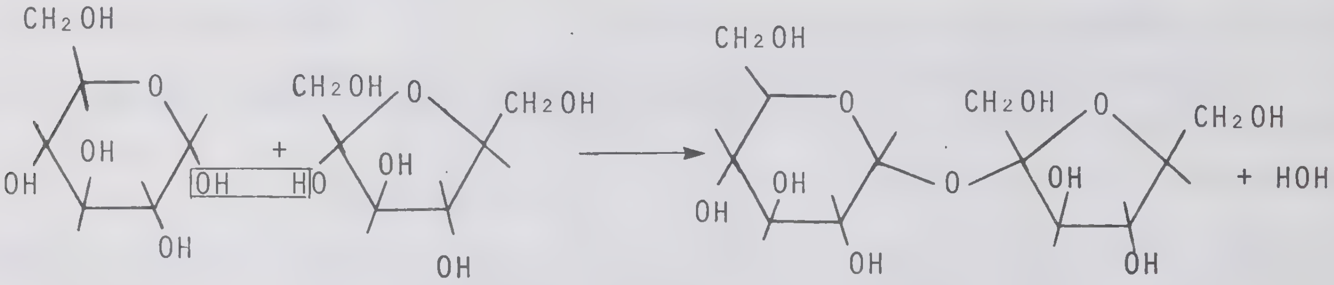
glucose, $C_6H_{12}O_6$



fruntose, $C_6H_{12}O_6$

Disaccharides

The most common disaccharide is sucrose or table sugar. Sucrose has the distinction of being the food compound that is sold in the greatest quantity. Sucrose can be thought of as a product of the monosaccharides glucose and fructose.

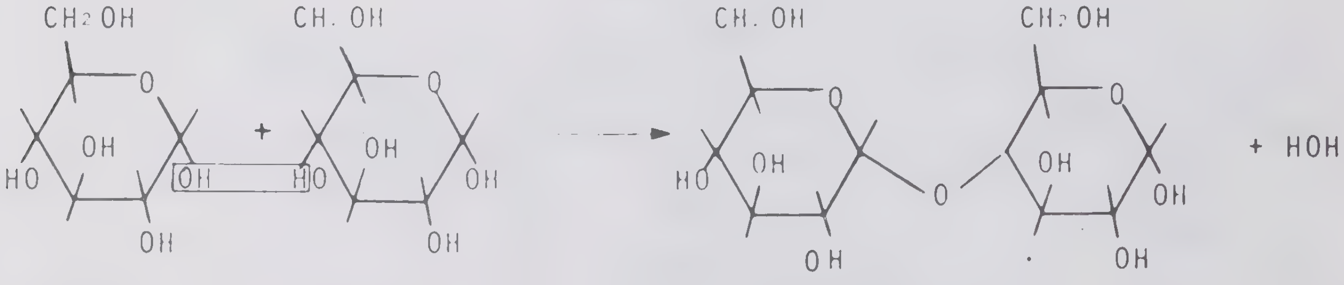


glucose (monosaccharide) fructose (monosaccharide) sucrose (disaccharide)

Water condenses out and the oxygen of the fructose unit bonds to the carbon atom of the glucose unit as shown in the product. In practise the reaction does not readily occur and sucrose is not manufactured in this way. The first synthesis of sucrose was done by R. V. Lemieux of the Prairie Regional Laboratory, Saskatoon, Saskatchewan and was described as "the Mount Everest of organic chemistry ". Dr. Lemieux was born in Lac La Biche, Alberta.

In practise sucrose is extracted from either sugar cane or sugar beets. The sugar beet industry is of major importance in Southern Alberta. Much of Canada's sugar beet industry is centralized here. Two plants, one at Picture Butte, built in 1936 and another at Taber built in 1950 extract the sucrose from the sugar beet and distribute it across the country.

Another example of a disaccharide is maltose which can be produced as shown below.



glucose glucose maltose (disaccharide)

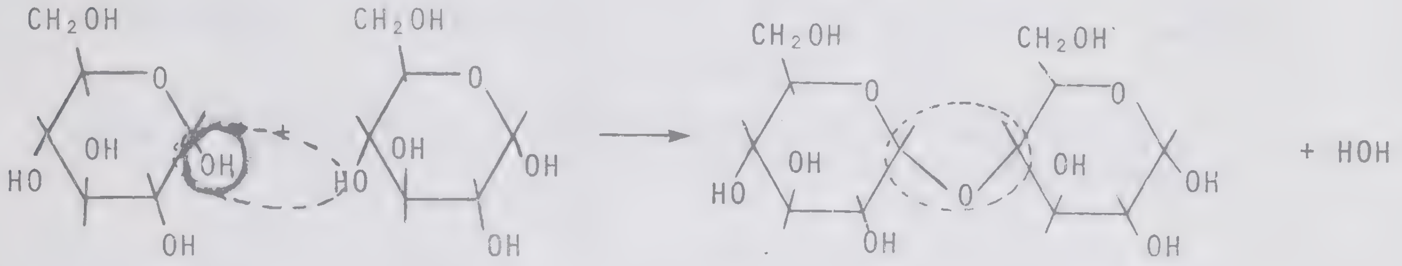
CARBOHYDRATES - NATURAL SACCHARIDES

Saccharides (sugars) are one of the most important foods of animals. The respiration of sugars (which is a catalytic process that eventually degrades the compounds into CO_2 and H_2O) releases much energy.

The most commonly encountered sugar is sucrose or table sugar. Most North Americans ingest large quantities of sucrose in most of the foods they eat and drink. Some other sugars are relatively common; honey is a mixture of glucose and fructose, and lactose (disaccharide of glucose and galactose) is present in milk.

Polysaccharides

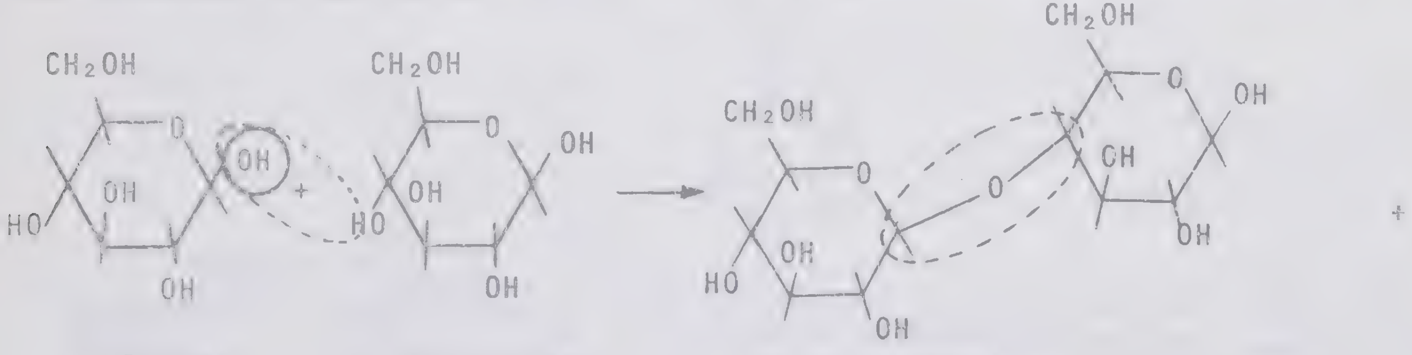
Condensation polymerization of monosaccharides results in *polysaccharides*. The first step in a typical reaction is shown below.



α-glucose α-glucose maltose

n(maltose) ⟶ starch

Continued reaction produces a polymer, in this case starch. The molar mass of starch ranges from 50,000 to several million grams per mole. Starches are the nutritional reservoirs in plants. In starches the glucose unit is called alpha glucose (α-glucose) and has the structure shown above. Cellulose, the structural material of wood and other plant products, is also a polymer of glucose but the monomers are beta glucose (β-glucose) units with the structure shown below.



β-glucose β-glucose cellobiose

n(celloboise) ⟶ cellulose

Notice the different position of the oxygen bonds in cellobiose compared to the oxygen bonds in maltose

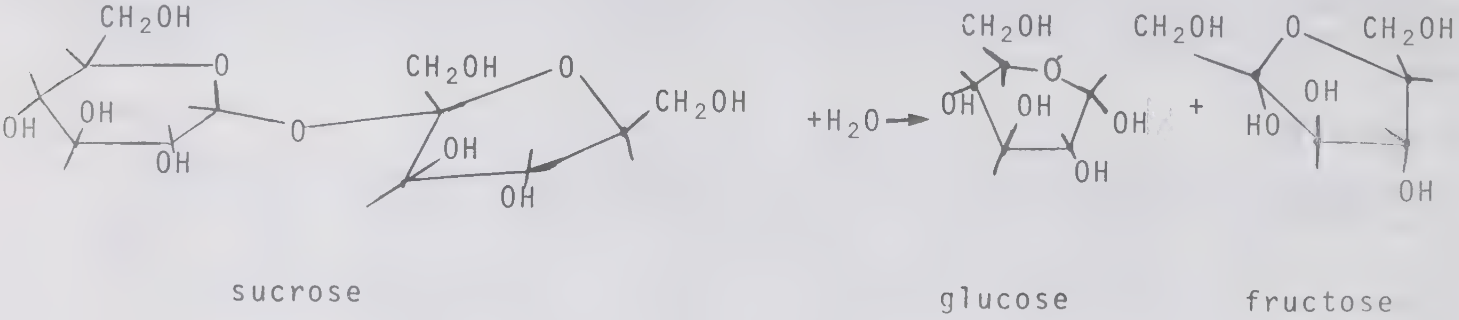
Continued reaction produces cellobiose with molar masses of 50 000 to 400 000 grams per mole. The difference in structure between starch and cellulose may seem trivial. However, the human body can digest polysaccharides of α-glucose but not those of β-glucose. Therefore starches are digestible by humans but cellulose is not.

CARBOHYDRATES - NATURAL SACCHARIDES

Digestion

Monosaccharides can be absorbed directly into the blood stream. Dissaccharides and polysaccharides (starch) must be hydrolyzed before being absorbed.

Example:



The monosaccharides are absorbed by the blood stream and are then taken to the cells where they become the main fuel for *respiration* resulting in energy, carbon dioxide and water.

Cellulose

Cellulose in plants carries out the same function as the skelton does for animals. It defines shape and gives strength. Cellulose in industry is used as indicated below.

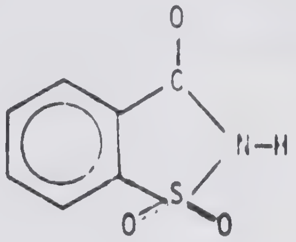
Table 02

Uses of Cellulose

Product of Cellulose	Used to Make
nitrocellulose	plastics, lacquers, explosives
viscose	rayon, cellophane, sponges
cellulose acetate	rayon, films, plastics
cellulose acetate butyrate	plastics
ethyl cellulose	plastics
mercerized fibre	cotton thread
carboxyl methyl cellulose	detergents
vulcanized fibre	cases, nonmetallic gears
parchment paper	records, diplomas

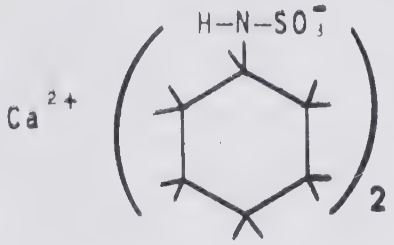
SYNTHETIC SWEETENERS

Since sugars (like most foods) can be used by the body to produce lipid (the body's way of storing·energy) and since North Americans are generally overweight, there has been a trend for using sugar substitutes. One example is saccharin, a compound that is about 550 times sweeter than cane sugar. Only a minute amount is necessary to provide the sweetness obtained from a teaspoon of sugar. The saccharin is not digested but excreted unchanged in the urine.



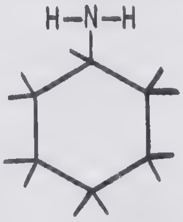
saccharin

Saccharin leaves a bitter aftertaste for many people. This led to its partial replacement by cyclamates which had no aftertastes.



calcium cyclamate

However, further research showed that under some conditions cyclamates were metabolized by cyclohexylamine.



(Note the similarity in structures between calcium cyclamate and cyclohexylamine.) Large doses of cyclamates were found to produce enough cyclohexylamine to cause cancer in rat bladders. Based on this information the sale of cyclamates was prohibited. However cyclamates are now back on the shelves in Alberta.

CARBOHYDRATES

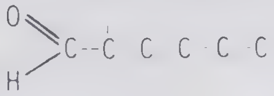
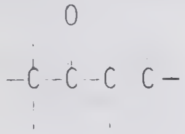
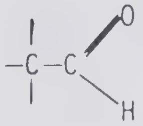
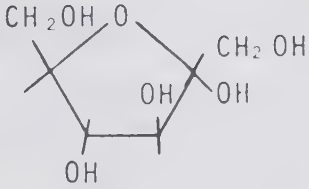
Write structural formulas for the following.

1. pentanal
2. 3-heptanone
3. acetone
4. formaldehyde
5. glucose (solid)
6. glucose (in water solution)
7. propanol
8. 4-octanone
9. maltose
10. general formula for carbohydrates

FOODS AND THEIR ANALOGS

CARBOHYDRATES

Classify and name the following compounds.

	Structural Formula	Class	Name
11.			
12.			
13.			
14.			

Write the names and structural formulas for examples of each of the following.

Monosaccharides

	Name	Structural Formula
5.		
6.		

CARBOHYDRATES

Disaccharides

	Name	Structural Formula
17.		
18.		
19.		

Polysaccharides

	Name	Structural Formula
20.		
21.		

FOODS AND THEIR ANALOGS
CARBOHYDRATES
RELATIVE SWEETNESS - LAB 02

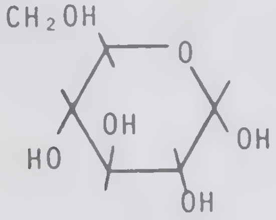
Purpose:

To determine the sweetness of various compounds and from this appreciate that different degrees of sweetness are possessed by different compounds.

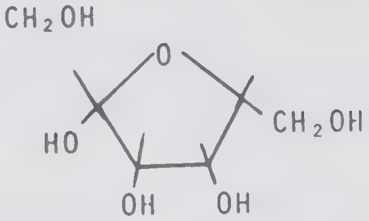
Background Information:

The following compounds will be tasted in an attempt to determine the relative sweetness of each.

Monoassacharides

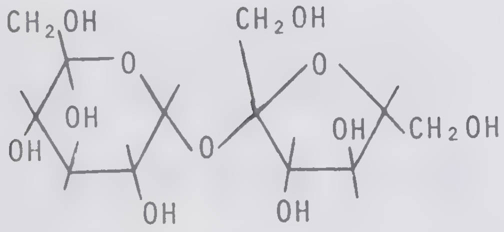


glucose



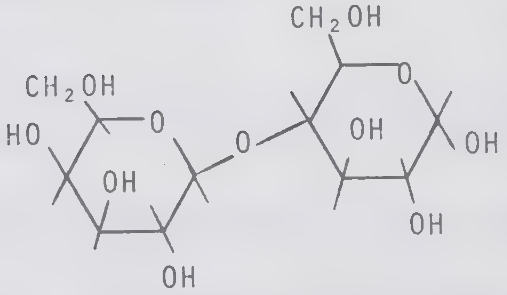
fructose

Disaccharides



glucose —— fructose monomers

sucrose

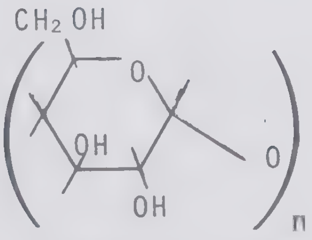


galactose —— glucose monomers

lactose

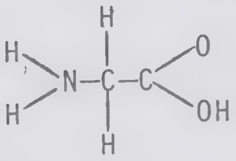
Galactose is not found in mammalian tissue so it must be synthesized in mammary glands. Lactose is found only in mammals.

Polymer



glucose monomer
starch

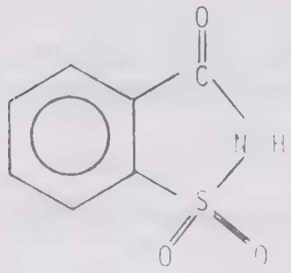
Amino Acid



glycine

RELATIVE SWEETNESS - LAB 02

Synthetic Sweetner



saccharin

Materials:

A sample of each of the following

- glucose
- fructose
- lactose
- sucrose
- glycine
- starch
- saccharin

7 - 75 mm watch glasses
- wooden splints

Procedure:

1. Using a scoopula obtain a small amount of each substance to be tasted from the stock bottle and place it on a watch glass. Label the watch glass.
2. Using a wooden splint pick up a small amount of starch from the watch glass and taste it to determine how sweet it is.
3. Repeat Step 2 for each of the substances accorded to the order listed below:

   starch, glycine, lactose, glucose, sucrose, fructose, saccharin

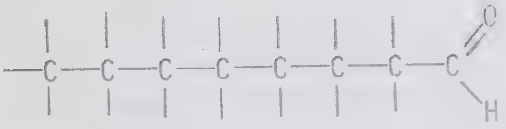
Questions:

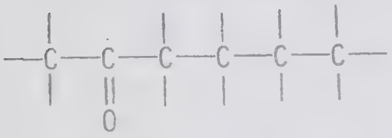
1. Rank the compounds in order of sweetness.
2. Is there any regular trend?
3. Is it necessary for a compound to be a saccharide to be sweet?
4. Are all saccharides sweet?

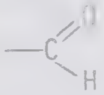
A REVIEW OF CARBOHYDRATES, NATURAL AND SYNTHETIC

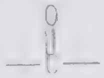
Review the unit on carbohydrates by answering the following questions.

1. The term carbohydrate is an unfortunate name for this type of compound because it suggests that they are carbon hydrates. Why do you suppose carbohydrate was chosen as the name for the compounds studied in this section?

2.  is an example of a(an)
______________________ and has the name ______________________.

3. 
$-\overset{|}{\underset{|}{C}}-\underset{\underset{O}{\|}}{C}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$
is an example of a(an) ______________________
and has the name ______________________.

4. Sugars which contain the  group are called
______________________.

5. Sugars which contain the 
$-\overset{\overset{O}{\|}}{C}-$
group are called ______________________.

6. The most common monosaccharides contain ______________ or __________ carbon atoms.

7. Glucose and fructose are similar compounds with the same molecular formula, $C_6H_{12}O_6$. However they differ in that fructose contains the functional group of a(n) ______________________ while glucose contains the functional group of a(n) ______________________.

8. In the naming of ketones the suffix ______________ is attached to the parent hydrocarbon, while the naming of aldehydes uses the suffix __________.

9. If a monosaccharide has the molecular formula $C_6H_{12}O_6$, why does a disaccharide not have a molecular formula $C_{12}H_{24}O_{12}$?

10. Plants store food mainly in the form of ______________________ (choose one from: lipid, protein, starch, sugar, cellulose).

A REVIEW OF CARBOHYDRATES, NATURAL AND SYNTHETIC

11. An enzyme, lipase, in saliva starts the digestion of starch. If it has an empirical formula $C_6H_{10}O_5$, write a chemical equation to represent the hydrolysis of starch.

12. Why was the use of cyclamates banned?

FOODS AND THEIR ANALOGS

FATS - CARBOHYDRATES - PROTEINS

1. Discuss the causes of bathtub ring.

2. What is the difference between starch and cellulose?

3. Briefly distinguish between respiration and digestion.

4. Why are some amino acids called essential by dieticians?

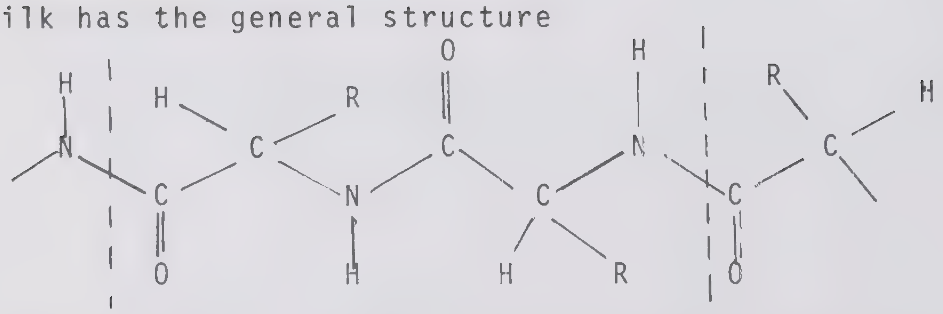
FATS - CARBOHYDRATES - PROTEINS

5. How does the body use fats, carbohydrates and proteins?

6. What is the name of the chemical process by which fats, carbohydrates and proteins are digested? What are the products in each case?

7. Cotton is almost pure cellulose. What would the monomers for cotton be? Name the dimer.

8. Silk has the general structure



Which synthetic polymer could be called "synthetic silk"? Why?

9. Detergents containing phosphates are very easily biodegradeable. What problem arises from their extensive use ?

10. Initial experiment on cyclamates led to their use being banned. Later they were allowed back on the shelves. Speculate as to the reasoning behind these actions.

11. The process of photosynthesis can be considered to be the reverse of the process of respiration of glucose. Write the equation for the photosynthesis reaction.

FOODS AND THEIR ANALOGS

FATS - CARBOHYDRATES - PROTEINS

12. Given the heats of combustion per mole of each of the following substances. Determine the heat of combustion per gram and then discuss the fact that carbohydrates are the most important source of food energy.

Substance	$\Delta H\left(\frac{kJ}{mol}\right)$	Molecular Formula	Molar Mass	$\frac{kJ}{g}$
glucose and fructose	2 807	$C_6H_{12}O_6$		
sucrose and maltose	5 648	$C_{12}H_{22}O_{11}$		
glyceryl tributanoate	8 113	$C_{15}H_{26}O_6$		

13. In industry cellulose is dissolved in a basic solution containing copper(II) tetraamino ion ($Cu(NH_3)_4^{2+}$). The dissoved cellulose is then extruded through fine nozzles into an acid bath to produce rayon. Rayon is pure cellulose. State whether or not rayon is a natural or synthetic polymer. Write a supporting argument for the choice.

ALCHEM 30

UNIT 0 - LAB INFORMATION

Saponification- Lab 01

Materials:

The list of materials below is given in class requirements on the left and individual station requirements on the right.

Day I

Class (16 Stations)	Each Station
16 - 250 ml beakers	1
16 - 100 ml beakers	1
16 - 75 ml evaporating dishes	1
16 - stirring rods with rubber policemen	1
16 - scoopulas	1
16 - crucible tongs	1
16 - bunsen burners	1
16 - 75 mm watch glasses	1
4 - stock bottles NaOH pellets	3.4 g
1 - lb lard - cut into 20 equal portions	23 g

55 - NaOH pellets in 16 vials	3.4 g
368 g - lard or grease (could be bacon grease or grease from other meats)	

Day II

96 - 18 x 150 mm test tubes	6
200 ml-1 M $Mg(NO_3)_2$ (29.7 g in 200 ml solution)	10 ml
200 ml-1 M $Ca(NO_3)_2$ (32.8 g in 200 ml solution)	10 ml
16 - scoopula	1
96 - #1 rubber stoppers	6
4 - stock bottles light oil (kerosene, benzene, cyclohexane) with a large dropper for each	a few drops

UNIT O - LAB INFORMATION

Production of Nylon - Demo 01

Materials:

The list of materials is given for 1 demo kit

1 - stock bottle sebacyl chloride
(when ordering it is also called sebacoyl chloride)
1 - stock bottle tetrachloroethene
(trichloroethene or carbontetrachloride will also work)
1 - 150 ml beaker
1 - 100 ml beaker
1 - stock bottle 1,6-diaminohexane
1 - pair of tweezers
1 - paper towel cardboard tube
1 - water bottle with distilled water

Place all of these on a cart or tray for the demonstration.

Relative Sweetness-Lab 02

Materials:

The list of materials is given for the class on the left and the individual station requirements on the right

Class (16 stations)	Each Station
4 - stock bottles glucose	small sample
4 - stock bottles fructose	small sample
4 - stock bottles lactose	small sample
4 - stock bottles sucrose	small sample
4 - stock bottles glycine	small sample
4 - stock bottles starch	small sample
4 - stock bottles saccharin	small sample
112 - 75 mm watch glasses (If there are not enough ask students to put 2 or 3 samples on each watch glass Students may use paper or cardboard sheets.)	7
32 - wooden splints (flat plastic coffee stir sticks)	1 per student
28 - scoopulas (1 for each stock bottle)	none

UNIT O - TEACHER INFORMATION

This unit, is an elective unit, may be expanded upon or shortened with no rious affect on the student. Much of the work is new but wherever possible estions relate to the core units.

Discussions should relate to problems involved in our misuse of chemicals d to problems involved in studying effects of chemicals on life.

e.g., When large doses of a chemical cause cancer in rats, does that mean that small doses over long periods of time will cause cancer in humans? Is the rat metabolism enough like human metabolism to tell? Should animals be sacrificed to save human life? How sacred is human life?

These questions could lead to some lively discussions. This unit might a good place to attempt to draw a line between scientific objectivity and lue judgements.

ggested Lab

Preparation of Detergents

jective:

1. To prepare a detergent.
2. To test some of the detergents properties.

terials:

.0 ml - dodecanol
.5 ml - (conc.) H_2SO_4
15 g - NaCl
17 ml - 2 M NaOH
drops -phenolphthalein
- 100 ml beaker
- 150 ml beaker
- wire gauze
1 - 10 ml graduated cylinder
1 - 25 ml graduated cylinder
1/2 beaker of ice

ocedure:

Obtain 11.0 ml of dodecanol in a 25 ml graduated cylinder and place it in a 100 ml beaker.

Obtain 3.5 ml of conc. H_2SO_4 in a 10 ml graduated cylinder and slowly add it to the dodecanol. Stir the solution slowly for 2 min. and then let it stand for 10 min.
Caution: Concentrated H_2SO_4 is corrosive.

Fill a 150 ml beaker half full of ice and add 15 g of NaCl. Mix the ice and salt. Add water to raise the level to 75 ml. Let the mixture stand.

DATE DUE SLIP

DUE Educ NOV 17'77	
Returned NOV 12'77	
DUE Educ NOV 16 '78	
NOV 14 RETURN	
DUE EDUC MAY 3 - '80	
MAY 3 RETURN	
DUE EDUC JUN 09'91	
MAY 29 RETURN	
F255	

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